# BME Design-Fall 2025 - DOMINIQUE GOODEN
# Complete Notebook

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## Table of Contents

# Team contact Information

ANA CLARA TOSCANO - Sep 10, 2025, 6:37 PM CDT

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# Project description

ANA CLARA TOSCANO - Sep 10, 2025, 6:35 PM CDT

**Course Number: BME 400**

**Project Name: Microvascular channel bioprinter shutoff valve**

**Short Name: Microvascular channel**

**Project description/problem statement:** Facilitate rapid switching between bioprinter input devices so that microchannels have rapidly decreasing diameter.

**About the client:** The Osteo Engineering Lab focuses on providing tools for the surgical reconstruction or regeneration of skeletal structures. Our research includes the use of Computer Aided Design (CAD) software to prepare patient-specific implants, implant components, and surgical devices that are rendered via additive manufacturing (3D printing). We have used these techniques to prepare restorative cranial implants for patients. However, a major focus of our preclinical research program has been the 3D printing of tissue engineered (resorbable) bone scaffolds and metallic skeletal fixation devices. In our bone tissue engineering research we seed cells, for example Mesenchymal Stem Cells (MSCs) and/or vascular progenitor cells, onto solid, 3D printed polymer scaffolds or within hydrogels. Those constructs may then be cultured, perhaps in a bioreactor, before implantation. The intent of pre-culturing scaffolds is to fill and/or coat them with tissue that the body perceives as a “tissue engineered bone graft.” Our work with 3D metal printing involves two alloys, NiTi, also referred to as nitinol or nickel-titanium, and magnesium (Mg) alloys. Our NiTi research currently focuses on stiffness-matched NiTi skeletal fixation devices, i.e., stiffness matched to the surrounding bone. Our Mg alloy research focuses on resorbing skeletal fixation devices.

# September 10 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 10, 2025, 6:43 PM CDT

**Title:** September 10 Team Meeting

**Date:** 10 September 2025

**Content by:** Steph

**Present:** Steph, Dominique, Sophie, Ana

**Goals:** Prepare for client meeting & PDS

**Content:**

- created a shared drive
- worked on questions for client meeting tomorrow (11 September)
- updated contact information in notebook
- worked on progress report
- divide up PDS

**Conclusions/action items:**

- Work on PDS for next week
- Client meeting tomorrow (11 september)

# September 17 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 17, 2025, 7:28 PM CDT

**Title:** September 17 Team Meeting

**Date:** 17 September 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi

**Goals:** Work on PDS and plan for client & advisor meetings

**Content:**

- Technical difficulties
- Talk about preliminary design ideas
- Discussing parts of the PDS
    - Go through individual questions about feedback on parts
    - Make sure to focus on the shutoff valve, not hydrogel or other parts - while good background, not the most relevant to the design of
        - More background will be kept in this version of PDS since it is beginning and we are figuring out project still

**Conclusion/Action Items:**

- Prepare for advisor & client meeting on Friday - review paper & look at Solidworks/STL files; meeting at 3:30 pm Friday
- Start thinking of preliminary design ideas (for next week's team meeting) & continue research
- Have PDS done by 5 pm tomorrow (Thursday) and finish Progress Report

# September 24 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 24, 2025, 7:41 PM CDT

**Title:** September 24 Team Meeting

**Date:** 24 September 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Ana,

**Goals:** Work on preliminary designs, form smaller teams to focus on parts of project, split up presentation, update progress report

**Content:**

- Discuss preliminary designs
    - Each team member shares their preliminary design ideas
        - Clamp - manually or automated pinching of tubing
        - Pringle - rotation plate cross section in CEVIK device with only 1 opening
        - Optimizing rotary valve - Find/put together a rotary valve that maintains function, as well as potentially quantifying the fluid, programmable within rotary valve
- Discuss & Work on Design Matrix
    - Discuss potential options
    - Pros and cons of each design
    - Sort out criteria for design matrix
    - Assign weights
    - Dividing up the design matrix to complete
    - Assign relative rankings as a team

**Conclusion/Action Items:**

- Questions for Josh:
    - Can you quantify the amount of fluid for each hydrogel
    - How does it print - rows
    - Does it print continuously (any breaks) between sheets
- Split up into small groups Friday
- Divide presentation Friday
- Continue research

# October 1 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 01, 2025, 7:52 PM CDT

**Title:** October 1 Team Meeting

**Date:** 1 October 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Ana, Mahathi

**Goals:** Finalize presentation & update progress report

**Content:**

- Sophie will clean up slides tomorrow
- Going through presentation
    - Talk through to look for repeated values
    - Everyone edit based on group suggestions
    - Run through presentation - with times for each person
    - Feedback on times & final suggestions

**Conclusion/Action Items:**

- Everyone practice at home to make sure their part is 2 minutes or a bit less
- Finish progress report by tomorrow about 7 pm
- Finish presentation slides by tomorrow

# 2025/10/09 - Computation Simulation

ANA CLARA TOSCANO - Oct 09, 2025, 7:07 PM CDT

**Title: Computation Simulation**

**Date:** 10/09

**Content by:** Ana

**Present:** Sophie and Ana

**Goals:** Create initial simulations and assign tasks

**Content:**

We assigned tasks for next week and started familiarizing ourselves with the programs.

**Conclusions/action items: Update group and Josh on next steps we see for the Testing Computational Dynamics**

ANA CLARA TOSCANO - Oct 09, 2025, 6:31 PM CDT


Download

**Solidworks_files.zip (3.07 MB)**

# October 10 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 10, 2025, 2:00 PM CDT

**Title:** October 10 Team Meeting

**Date:** 10 October 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Ana

**Goals:** Discuss Preliminary Report

**Content:**

- Confirmed meeting with advisor Wednesday at 6:45 on zoom
- Discussing preliminary report
    - Individual questions
    - Do we need to include discussion & conclusions
    - Need to find specific small clamp - specifically looking at pinch clamps
    - Have more people work on Solidworks
    - Brief overview of materials under proposed final design
- With other considerations for the project, it might be too much for the semester/year - narrow to areas we think we can get done

**Conclusion/Action Items:**

- Clarify scope with client later

# October 17 Prototyping Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 17, 2025, 3:03 PM CDT

**Title:** Prototyping First Meeting

**Date:** 17 Oct. 2025

**Content by:** Steph

**Present:** Steph, Dominique, Mahathi

**Goals:** Get on the same page for the team

**Content:**

- Review meeting notes from Wednesday
- Go through some spreadsheets for current purchasing ideas
    - One motor Dominique proposed has a good design, might be too try to make a version ourselves
- Look at Blue Room for potential fabrication materials

**Conclusion/Action Items:**

- Start preliminary fabrication next week

# October 22 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 22, 2025, 7:41 PM CDT

**Title:** Team Meeting

**Date:** 22 Oct. 2025

**Content by:** Steph

**Present:** Steph, Dominique, Mahathi, Sophie, Ana

**Goals:** Plan for Show and Tell; status update for groups/individuals

**Content:**

- Individual Updates
  - Steph - Worked on modeling CEVIC solidpart
  - Sophie - modeled rotary part; picked up print - 2 parts of CEVIC did not print properly, will likely have to either split Steph's CEVIC or individually model the parts; still working on CFD
  - Ana - watching videos & demonstrations of CFD simulations; since not number 1 priority, can assign some things for show & tell; doing research on competing designs to check if there are products out there that fit our requirements
  - Dominique - working on mechanisms to regulate flow; worked on Solidworks part to make our own pinch, involving servo pinching tubing
    - May not fully pinch tube; are looking at making our own pinch; servo motors are weak so may need stronger motor
  - Mahathi - Researching on pinch valve we found on Friday
- General group updates
  - Looking like CFD will need to be much simpler than KSMs & CEVIC
  - May have to choose different motor for more torque to squish tube
- Question about trainings
  - Page of options
  - Human subjects - difficult but can get done
  - Welding - very fun and not too hard
- Show & Tell next week (Oct. 31)
  - Hope for a servo & gear to be able to show rotated
  - Maybe split CEVIC too?
- Goals
  - Print IRE, gear; pick up servo
  - Work on basic simulation for show & tell
  - General code for servo rotation

**Conclusion/Action Items:**

- Work on servo & gear to have for show & tell; leaning towards Arduino for show & tell
- Continue working on modeling CEVIC

# October 29 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 29, 2025, 7:11 PM CDT

**Title:** Team Meeting

**Date:** 29 Oct. 2025

**Content by:** Steph

**Present:** Steph, Ana, Sophie, Mahathi

**Goals:** Prepare for show and tell

**Content:**

- Sophie printed PLA part of split CEVIC and connected it to Steph's motor and it worked! (see attached video)
- Will print in resin eventually
- Next step is to make a stand to somehow hold the CEVIC and motor
- Next meeting with Josh ask about requirements for code
- Acquired a locker

**Conclusion/Action Items:**

- Finish progress report
- Bring project supply Friday

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 29, 2025, 7:00 PM CDT

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**IMG_2354.MOV (11.7 MB)**

# November 14 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 4:24 PM CST

**Title:** Team Meeting

**Date:** 14 Nov. 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Mahathi, Ana

**Goals:** Prepare for show and tell

**Content:**

- Testing
  - Functionality - does it work as we expect; can test circuit
    - CEVIC and electronics testing
    - Metrics for electronics - make sure it spins, test timing and angle
  - Cells - run through CEVIC and tubes to make sure cells can survive - cytotoxicity & durability (Plan for next Thursday)
  - Durability - no fluid, just spinning
  - Electronics
  - Can think of 2 or 3 objectives for each test - look under preliminary report
- Ana will run updated simulation this weekend
- Future directions
  - Modify IRE - will be focus of design and final report
  - Could look at heat and printing angle for next semester
- Poster/Final deliverables
  - Focus on IRE & simulation
  - Testing done by Thanksgiving break
  - Have poster done & sent to print by the Tuesday after spring break
  - Division
    - Sophie - Background & motivation
    - Mahathi - Design specifications
    - Ana - Testing
    - Steph - Final model
    - Dominique - Results & Future work
- Final report - similar sections
- Look for program for 2D drawings

**Conclusion/Action Items:**

- Connect with smaller groups
- Do testing

# November 19 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 19, 2025, 7:05 PM CST

**Title:** Team Meeting

**Date:** 19 Nov. 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Dominique, Mahathi

**Goals:** Make sure everything is ready for testing & do circuit testing

**Content:**

- Brief recap
  - Sophie printed parts
  - We plan to do durability testing and cell testing (cytotoxicity & shear)
  - Cytotoxicity - mainly shear since biomed clear is already tested to see if it kills cells
  - Will write protocol for cell testing
  - Ana did simulation for 2 hours today - it failed but did not give error, was just loading, then when chose material, stopped at about 30% for about an hour then stopped - have a sense of what want to change to see if can fix; got CAD file to load
- Protocol how to test circuit (tonight)
  - Measure voltage/current

**Conclusion/Action Items:**

- Prepare for individual small group testings

# December 1 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 01, 2025, 8:27 PM CST

**Title:** Team Meeting

**Date:** 1 Dec. 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Mahathi, Ana

**Goals:** Finish the poster to send to client & advisor for feedback before printing

**Content:**

- Discuss each section on the poster and make edits
- Split Testing results & Future work into 2 sections
- Condensing motivation & background

**Conclusion/Action Items:**

- Send poster to receive feedback as soon as possible

# December 3 Team Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 03, 2025, 8:01 PM CST

**Title:** Team Meeting

**Date:** 3 Dec. 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Mahathi, Ana

**Goals:** Practice poster

**Content:**

- Check on when LabArchives final is due
- Finish report hopefully by next Thursday/Friday and aim to send to Josh early
- Clamp design in final report
    - Revise design matrix
- Adjust design specifications in speech based on Dr. P's feedback
- Give a run through once people arrive on Friday
- Run through practice
- Practice on our own and early on Friday

**Conclusion/Action Items:**

- Practice on our own and early on Friday

# September 11 Client Meeting 1

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 11, 2025, 3:14 PM CDT

**Title:** September 11 Client Meeting

**Date:** 11 September 2025

**Content by:** Steph

**Present:** Steph, Dominique, Mahathi

**Goals:** Learn client expectations and project information

**Content:**

- CEVIK device - how it works, how it used to work
- shutoff valve is the issue
- Introduce selves and specialties
    - essential experiences are flow of fluids (water, gel) & instrumentation (things that can flow) - modeling of flow; design of mechanical device which flow can happen
- Goal: print microvasculature; create blood vessels that reach down to capillary scale - current gap in field
- Chaotic printing - Kenics static mixer (KSM) - split and twist flow of inks - go to 2 inputs to layered structure of 4
- Print layered structure in sheet - allows to seed with endothelial cells & create/grow microvasculature
- Problem: idea of branching channels
    - Can add sequential elements to double number of layers to KSM
    - 10-30 micron size critical for capillaries
    - Need big blood vessels too (order of 1 mm) to suture to existing blood vessel to integrate with host vasculature
- Current method: CEVIK device
    - Use multiple KSM with diff number of elements to combine and print through 1 nozzle
    - Last level is seeding with cells and growing blood vessels
    - Nozzle in shape of fan to print sheet
    - Inputs - gel & fugitive ink (wash away to leave behind channels)
    - Problem: issues when switching/branching between K mixers - want to look how fluids flow in device and relation to each other, and relation to device; want to design device so flow is highly controlled to print branching architecture
- Emphasize
    - Look **Figure 3**
    - issue quite limited - have motorized rotary valve that will send flow to different KSM
    - In A: manual shutoff when you go from 1 KSM; want to connect quickly & in straight line; every cell must be 50-70 um of a capillary
    - In B: All different inputs to KSM; Cannot control when switch to next one - cannot stop flow from pervious one
    - Hydrogels fed in manually
    - Both ink flowing at same time
    - Problem when going from one KSM to next one, cannot stop the flow
    - Bioprinting - since start (2000s) - only done with syringe - hydrogel coming out of syringe
    - Sheets are helpful b/c can wrap around graft and supply blood (this case specifically bone); usually in surgery have to wrap bone in muscle
        - Capillaries can form within hours, but what provides them with blood can take weeks to months
- Monetary Tech (Mexico) is where device originated
- Figure C in schematic - what part of process need animation
    - In figure E - many KSM all sticking into printhead (CEVIK) - shut off white part
        - Time (maybe in Lab view) to stop the dripping
        - Want to move fan on top of something you are printing
        - What is going on in KSM is not as relevant, more how to cut off the dripping
    - C - turn on 1 KSM - whole thing is 1 channel, then 4 channels
- Size of channels

    - channels couple cm tall, 1 cm across (very roughly)
    - flow rate - 1 mL to 1.5 mL per minute
    - Diameter - smallest artery 150 microns in diameter; smallest capillary 10 microns; must be capillary within 50-70 microns of every cell
    - Arteriole - in microvasculature - between artery and capillary - about 150-30 microns
- B - switch KSM using a program to switch which ones
- Become familiar with CAD files and what can be done for the shutoff
- Computational fluid dynamics modeling; Navier stokes & non-Newtonian fluids
- **Arteries - murphy's law**
    - As branches occur, get reduction of flow
- One problem was resolution of printer; how printing KSM
- Ask Paul - how we spend time on project - meet with Josh to get through
- Lab currently in Columbus & still getting set up here, so cannot see everything yet
- resource: when testing, Josh has been in contact with 1 of inventers of bioprinting; access to rheometer
- Materials
    - using 3% gelMa & 2% sodium alginate - usually heat to allow flow through KSM
    - print with clear resin
    - KSM & CEVIK usually printed with biocompatible resin (clear)

**Conclusion/Action Items:**

- meet with Josh about once a week

- figure out times on Wed & Friday that we could meet with Josh

# September 19 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 19, 2025, 4:26 PM CDT

**Title:** September 19 Client Meeting

**Date:** 19 September 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Josh

**Goals:** Project update & next steps

**Content:**

- Only 1 KSM active at a time
- Rotary valve has not yet been fully implemented
- Eclear resin
- Shutoff valve
- 2 syringes - one with hydrogel contents, one with fugitive ink
    - Loaded into syringe pump
    - Tubing goes to each rotary valve, and rotary valves are connected to KSM elements
        - Rotary valve - 1 input and rotates on a dial to different outputs
    - Issue with rotary valve - do not have a lot of control when to stop flow, even when switching between which output - causes pooling effect - flow from multiple KSMs ruin branching effect
    - Make sure branching is not effected after
- Look into rotary valves & what is available - compile some and send to Josh - look for some that are integrated with LabView or already programmable
    - All pressure comes from syringe pump to control flow rate
- Rotary valve is programmable via arduino & integrated with LabView
- Categories for project
    - Simulation/computational fluid dynamics would be very helpful (1-2 people doing this would be good)
        - Valuable b/c the people who invented this technique, they have used some sort of modeling to validate they are producing the layered architecture - this lab has not done it at all yet
        - Has not computationally validated the CEVIK device - if all the liquid is combined is it reliable
        - Industry standard: Ansys - fluent
        - Once you figure how to model, then can figure out how to optimize
    - Design/redesign of CEVIK may happen
        - Switch between KSMs
- Question for Dr. Dean: do we need to worry about intellectual property; if design changes, do we  get credit
- Trying new approach by sectioning KSMs
    - Split along individual elements - can rotate individual elements "in and out of plane"
    - Be able to individually change how many channels there are - not tested yet
- Focus most work on CEVIK
- What "shutoff valve" means
    - means switching between the elements and the problem with the extra fluid flow
    - All flow driven from syringe pumps
- Notes for 3D printing
    - Formlabs 4; Standard clear resin
        - Eventually worry about sterilizable & biocompatability
    - Reduce touch point size of supports
    - Maybe do not cure until after supports are removed

    - Do not slice with internal supports

**Conclusion/Action Items:**

- Print devices
- Start thinking how to divide project into smaller parts
- Start generating list of what materials we need

# September 26 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 26, 2025, 3:54 PM CDT

**Title:** September 19 Client Meeting

**Date:** 19 September 2025

**Content by:** Steph

**Present:** Steph, Dominique, Sophie, Ana, Mahathi, Josh

**Goals:** Project update & next steps

**Content:**

- Start discussing designs in design matrix
- Discuss ratings and top design
- Ideally test all designs
- Currently most convinced by the second idea (rotating element)
- Working on getting syringe pump - hopefully come down next week to observe printing process
- Syringe pump - how it should be used, specifically using it to control flow
    - traditional: inject at constant rate
    - Switch to KSM - pause syringe pump and switch flow on rotary valve
    - Before: pause syringe pump & withdraw a bit and would help draw back some
- How to know when to switch KSMs
    - Variable - final product want it to be at regular interval for 1 cm segment, etc.
- Currently printing just 1 row as 1 hydrogel
    - Small so will go into rat femur so very small
- Question about paper
    - In current system, is there any considerations for excess/waste
        - Biggest source of waste right now is tubing - remaining gel in tubing
        - Residue left over in CEVIK when done printing
- Plans for next week
    - Computational tool using
        - Comsol & solidworks
        - Josh recommends ANSYS - industry standard - specifically fluid dynamics model - "Fluent"

**Conclusions/Action Items:**

- Start printing design 2
- Finalize software we are going to use this week
- Prototype some designs we drew up

# October 3 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 03, 2025, 4:14 PM CDT

**Title:** October 3 Client Meeting

**Date:** 3 October 2025

**Content by:** Steph

**Present:** Josh, Steph, Sophie, Dominique, Mahathi

**Goals:** View printing process

**Content:**

- Could do cell viability test on cells
- Try to figure out how to measure shear
- Can put cells (ie. cells from 511) through printing process and see how they survive
- Bioinks are being heated on heat plates to make sure the inks are liquid enough to be printed
- Diameter of tubing off syringe is 1/16 inch
- GelMa 3%, 2% sodium alginate, 0.1% LAP - crosslink help
- Process
    - Draw up fluid into 1 syringe
    - Calcium chloride crosslinks sodium alginate; UV crosslinks GelMa
    - Flick syringe to get bubbles to top
    - Syringe pump is very finicky - (could look into design there?)
    - Hydroxy ethyl cellulose (HEC) - fugitive ink (will wash away) - less expensive material than gel - better to experiment with HEC and sodium alginate for that reason
    - Load syringes, reattach tubes
    - Small black knob locks syringes to rail
    - 2 modes for syringe pump
        - Withdraw (when you load pump, do not have to withdraw)
            - Hit mode - select - infuse - choose amount
        - Infuse
    - Have to update what kind of syringe, and set rate - 1.5 mL/min
    - Usually work with 20 mL syringes
- Want to do more research on print surfaces - currently using well plates, well plate lids, petri dishes, etc.
    - When start, hold up tubing and KSM to get air bubbles out - once all air bubbles are removed, can start printing
    - Slowly drag across surface you are printing on
    - Hard to see channels until crosslink
    - First apply calcium chloride (Usually printed into a vat of calcium chloride, but that is not viable for now)
    - Apply UV - Turn on and go across the sheet to cross-link it - done for about 60 seconds - when contain cells, have to be more careful as you may damage cells
    - After crosslinking, can see 2 different inks
        - White is GelMa; Clear is fugitive ink

**Conclusions/Action Items:**

- Start prototyping/finding software this week
- Look at temperature - something to keep syringes warm

- Think about optimal KSM printing angle

# October 10 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 10, 2025, 3:55 PM CDT

**Title:** October 10 Client Meeting

**Date:** 10 October  2025

**Content by:** Steph

**Present:** Josh, Steph, Ana, Sophie, Dominique

**Goals:** Clarify scope and update current progress

**Content:**

- Recap our sections for the week
    - Want to figure out and learn how to do ANSYS
    - Hope to re-print CEVIK & print split CEVIK (2nd design)
- Clarify scope
    - Focus on our main problem statement
    - Hopefully next semester can do additional things
- Cell testing - mouse pre-osteoblast
    - General cytotoxicity & push through syringe to make sure they survive
- While prototyping, think about materials we need
    - Tubing, clips, motor, etc.
- Purchasing - create account and can charge through it
- For makerspace - "Osteoengineering Lab"
- Same type of tubing through entire system; silicone; inner diameter is 1/16 inch
- Cells seeded in GelMA
    - Mix cells in beaker with GelMA

**Conclusion/Action Items:**

- Finish report by Monday - send a draft to Josh to review
- Work on designs
- Goal:
    - simulate fluid in a tube
    - Re-print and have a preliminary products list

# October 17 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 17, 2025, 3:51 PM CDT

**Title:** October 17 Client Meeting

**Date:** 17 October  2025

**Content by:** Steph

**Present:** Josh, Steph, Dominique, Mahathi, Sophie

**Goals:** Update on current progress

**Content:**

- Discuss current motor options
    - Found one in blue room - tubing probably too small
    - servo motors may be a way to go; would like to try for design 1 and 2
- CEVIC split is hopefully printed & new CEVIC and KSMs
- May want to make STL of CEVIC back into solidpart
    - Might be some tools
- Look up how the different motors work
- Within valve subteam
    - someone work on valve, someone work on rotary, someone work on programming interface
- Labview is the way we are looking to program
    - Practice with valve we found and run some water through
- Progress on CFD
    - Do not worry too much if it starts interfering with deliverable - feel free to focus on deliverable

**Conclusion/Action Items:**

- Work further on prototyping this week
- Continue on CFD

# October 24 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 24, 2025, 3:54 PM CDT

**Title:** October 24 Client Meeting

**Date:** 24 October 2025

**Content by:** Steph

**Present:** Josh, Steph, Ana, Mahathi

**Goals:** Update on current progress and plan for next week

**Content:**

- For CFD, try to model fluid in a pipe
  - Shear of material, shear stress, maybe velocity but maybe not
- Update on CEVIC - use part and credit
- Update on Dominique's box
- Acquired servo motors
- Hope to test after show & tell
- Meetings every other week
- Purchasing
  - Usually through approved vendors
  - Depends how the client wants it
  - Reach out to Paul & Dr. Dean about client payments

**Conclusion/Action Items:**

- Prepare for show & tell

# November 7 Client Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 07, 2025, 3:55 PM CST

**Title:** November 7 Client Meeting

**Date:** 7 November 2025

**Content by:** Steph

**Present:** Josh, Steph, Sophie, Ana, Dominique, Mahathi

**Goals:** Update on current progress and plan for next week

**Content:**

- IRE feedback from show & tell
  - Controlling fluid flow (backflow); concave
- Printing current CEVIC - biomed clear, will likely have to dremmel
- Feedback on Symvascular for simulations
  - Free, 2 professors that are good at those simulations, will likely consult/reach out to them
- For Fluent, finished simulation to calculate velocity - made some assumptions that not fully comfortable with
  - Laminar flow seems to be an ok assumption
  - Used water
  - Probably need density & viscosity - Josh can provide both
  - Start with values in simplified ones then go to more complex
- Mahathi found relay in blue lab
- Dominique
  - Clamping might not produce enough torque
  - One idea, push-stopper to clamp material
  - Creating a new design matrix to have different ways to test different clamping mechanisms
  - Maybe think about a system where you clamp every tube except one - relaxed state is clamped, on state is released

**Conclusion/Action Items:**

- Work on goals this week
- Focus now on modifications & testing

# November 20 - Testing

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 20, 2025, 7:07 PM CST

**Title:** November 14 Client Meeting - Testing

**Date:** 14 November 2025

**Content by:** Steph

**Present:** Josh, Steph, Sophie, (Ana)

**Goals:** Test shearing of cells through device

**Content: Procedure**

- Place GelMa tubes on hot plate to thaw - about 60 degrees C
- Syringe filter - 0.22 microns
- Discussing different points to measure cell viability across - in Gel, after push through syringes, after cured
    - After cured would require immunostaining or something else because it will be solid so cannot use hemocytometer
- check cells under microscope - Sophie will tell confluency
- gel preparation: 10X PBS to 1X
    - put 10 mL 1X PBS into pre-portioned GelMa powder and add stir bar
    - Sodium alginate
        - Weigh boat for HEC and alginate - values in chart
        - 0.333 g sodium alginate, 0.12-0.15 g HEC (2 separate beakers), 15.625 mL PBS
        - 6.66 mL
    - When stirring at 70 C, cover beakers with weight boats
    - Finish with sterilizing and adding cells next time
- Cells dead :( - reaching out to Dr. P for more and what to do

**Conclusion/Action Items:**

- Hear back from Dr. P
- Hopefully continue on Tuesday
- **Add LAP**

# September 12 Advisor Meeting 1

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 12, 2025, 1:55 PM CDT

**Title:** September 12 Advisor Meeting

**Date:** 12 September 2025

**Content by:** Steph

**Present:** All team members

**Goals:** Be advised

**Content:**

- introductions
- discuss our understanding of project
    - overview of project
    - new project
    - meeting with PhD student weekly
- meeting at 3:30 next week
- email best to send progress report
- still figuring out exact part of project

**Conclusion/Action Items:**

- email PhD student for meeting times and CAD files
- finish PDS
- Meet at 3:30 next week

# September 19 Advisor Meeting 2

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 19, 2025, 3:51 PM CDT

**Title:** September 19 Advisor Meeting

**Date:** 19 September 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Josh

**Goals:** Project update & next steps

**Content:**

- Notebook checks - will not be weekly, just at end of semester for us
- Make sure to understand the paper
- Can print the files in Wendt - use overall charge account (BME Design)
- Think about outreach sooner than later
- Preliminary Presentations in 2 weeks
- Break up project into smaller groups based on interests
- By end of semester: something that can consistently branch channels in a hydrogel sheet
- Video of device in action - video of setup with food coloring
- Electronics - using rotary valve which can switch between different inputs. Do not have any rotary valves here.

**Conclusion/Action Items:**

- Check out the 3D printed CEVIK device and KSMs in Josh's office
- Prepare for presentations in 2 weeks

# September 26 Advisor Meeting 3

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 26, 2025, 2:04 PM CDT

**Title:** September 26 Advisor Meeting

**Date:** 26 September 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Discuss PDS and maybe design matrix

**Content:**

- Design matrix
  - Discuss 3 designs in matrix
  - Concern - bubbles getting in the system
  - Looked at aliquot or Y connector
- PDS
  - We have good options
  - All 3 things in matrix are plausible
- Split into 2 groups
  - Fluid dynamic analysis - Ana, Sophie
  - Prototyping - Mahathi, Dominique, Steph
- Split up presentation

**Conclusion/Action Items:**

- Meet with Josh later
- Discuss outreach(?)

# October 15 Advisor Meeting

SOPHIA SPEECE - Oct 15, 2025, 7:30 PM CDT

**Title: October 15 Advisor Meeting**

**Date:** 10/15/25

**Content by:** Sophie Speece

**Present:** Sophie, Mahathi, Steph

**Goals:** Touch base with advisor before he is gone once again this Friday.

**Content:**

Prof. Campagnola is gone this Friday

Include more explicitly the 'why' behind the project in the beginning of the paper and the poster.

Have we clarified who is doing what? Yes

Have we started using COMSOL/ANSYS and Labview? Yes

Goals for end of semester: have a working prototype to test, have a working fluid model

Make the drawings into a more CAD type diagram for the final poster and presentation.

**Conclusions/action items:**

# October 24 Advisor Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 24, 2025, 1:50 PM CDT

**Title: October 24 Advisor Meeting**

**Date:** 24 October 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Dominique, Mahathi

**Goals:** Update on show and tell and other progress

**Content:**

- Dominique has created Solidworks prototype for compressing tubing
- Mahathi has researched valves
- Sophie has created gear for IRE design
    - Goal for show and tell is to have rudimentary motor attached so we can see it spin
- Steph has worked on CEVIC and met with Jesse to finish model
- Ana hopes to have a working CFD model
- Try to space out Josh meeting (maybe every other week)
- Try to finish training by next week but end of semester ok
- No critical comments on presentation; make sure to buff up why this project is needed

**Conclusion/Action Items:**

- Prepare deliverables for show & tell
- Next week show & tell; Tong lecture - keep regular time and place for advisor meeting

# November 7 Advisor Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 07, 2025, 1:51 PM CST

**Title: November 7 Advisor Meeting**

**Date:** 7 November 2025

**Content by:** Steph

**Present:** Steph, Sophie, Mahathi

**Goals:** Update on show and tell and other progress

**Content:**

- Recap Tong lecture
- Sophie next thing
  - print CEVIC and gear with tighter tolerance and correct material
  - Designing something to house motor and CEVIC together
  - and Ana will follow up with Prof. Witzenburg(?) about CFD
- Mahathi
  - Look in Blue Room for relay
  - By next week: have sample protocol
- Steph
  - Modify IRE, help with testing
  - Maybe look into DC motors
- Dominique
  - Working on clamp design
- Ana
  - Continue to work on CFD

**Conclusion/Action Items:**

- See above for current workings
- Will meet with Josh this afternoon

# November 14 Advisor Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 1:52 PM CST

**Title: November 14 Advisor Meeting**

**Date:** 14 November 2025

**Content by:** Steph

**Present:** Steph, Ana, Sophie, Dominique, Mahathi

**Goals:** Update on current progress & plan

**Content:**

- Sophie - passaged cells, modeled holder for CEVIC and servo motor
  - Feed them vitamin C & something, turn into bone
  - Hope is to do shear & toxicity testing
- Steph - not too much, did generic research
- Ana - worked on protocol for simulation updated with assumptions from other papers
- Dominique - expanding on clamp design and thinking of different clamp designs
- Mahathi - found relay in 201; can adjust angles the gears rotate at
- Will have wrap-up meeting after poster
- Aspirations for posters
  - have IRE mostly working, may not have full program or button
  - Ana's fluid simulation
- Deliverables
  - Can have until the Monday of finals week (15th)

**Conclusion/Action Items:**

- Have team meeting later, will discuss final deliverables and future plans

# November 21 Advisor Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 21, 2025, 1:56 PM CST

**Title: November 21 Advisor Meeting**

**Date:** 21 November 2025

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Mahathi

**Goals:** Update on current progress & plan

**Content:**

- Update: cells dead :(
- Made hydrogels with Josh yesterday, cleaned up protocol, will test over Thanksgiving if we can get cells
- Hope to get cells ASAP
- Circuit testing: can switch between KSMs
    - Will get protractor to check angle - better to use ImageJ for accuracy
    - torque is good to measure
    - Talked about using force sensor - can use voltage and convert it?
    - Use number of teeth as way to calculate displacement/speed
    - Speed may be good to measure to make sure switching KSMs fast enough
    - Still movement of motor during delay
- Staining
    - Calcein for live cell part - only crosses live membranes
        - Can take section of gel and manually count it
        - Shows up green on fluorescence microscope
        - Excites 490, emission 530
    - Trypan blue - dead staining
    - P iodide is fluorescence for dead cell staining
        - PI shows up as red
    - If it shows up as neither, probably on its way out

**Conclusion/Action Items:**

- Check teaching lab for Calcein
- Have poster done & sent to Campagnola by the Tuesday Dec. 2
- Monday the 15th have notebook done

# December 11 Advisor Meeting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 11, 2025, 11:34 AM CST

**Title: December 11 Advisor Meeting**

**Date:** 11 December 2025

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Dominique, Mahathi

**Goals:** Wrap up semester

**Content:**

- Poster wrap-up
  - Figures look nice
  - Make sure to include what capillary network actually looks like
  - Prototype was good
- Change background based on Dr. Dean's advice
- Final report
  - Add picture
  - Change background
  - Do not need revised PDS
- Pick a journal in the spring to choose to format our final 402 report for - write in proper scientific format

**Conclusion/Action Items:**

Make final changes to report

Have a break

# Feedback from Show and tell

DOMINIQUE GOODEN (degooden@wisc.edu) - Nov 07, 2025, 3:45 PM CST

Date: 31 October 2025

Present: All

Content by: Dominique and Sophie

Goal: Summarize client received on our design and evaluate areas for improvement.

1. Convert the CEVIC gear to a more concave downward/deeper shape to better accumulate fluid and for easier rotation.

2. Vacuum mechanism (potentially adding another hole that instead would be replaced with a collection container)

3. Sweeping mechanism where we 'sweep' the IRE with fluid that accumulated onto it from the other KSMs. Where it would go would be TBD.

4. Talk with BME 505 or BME 330 professors for extra guidance on CFD modeling.

5. Clamp design pinch attachment likely will not produce enough torque to effectively clamp the tubing. It was suggested that the same motor could be used to design a tool to 'push' the clamp towards the tubing (almost like a horizontal stopper)

6. Create a raised circular stop on the top surface of the IRE. The stopper would come in contact with the bottom of the KSM to prevent excess downward fluid accumulation. Anticipated difficulty with rotating the IRE appropriately

ROUND TWO

1. Is there a rotational delay in the servo? May need a better motor to get a more instantaneous switch between outputs for the IRE design. Think about whether automation is volume driven or time driven (rotate this many degrees after this many seconds)
2. Dr. Swarez for BME 330 CFD, 505 biofludics, look up the professor, sounds like they model blood flow and have people bring in projects to model. Dr. Whitzenberg is a good contact (recommended by more than two people)
3. Could have a slow rotation rather than a quick 60 degree change? Will each KSM resolution be given the same amount of time while printing (resulting in equally sized sections of each resolution)? Need to ask Josh. Design consultation with Jesse! He is very good with CAD
4. Software called SIMVascular (free software to determine flow rates after importing stl, good for blood and more organic flow). Dr. Whitzenberg and Dr. Alehandro Alzate from 505. Look into a MatLAB program so that it is automatable and researchers can put different inputs. Include a circuit box to house electronic components
5. Include both a program and a physical button? Or a UI?

# Material and Expense Report

SOPHIA SPEECE - Dec 15, 2025, 9:59 PM CST

**Title: Material and Expense Report**

**Date:** 12/15/2025

**Content by:** Ana Toscano, Sophie Speece

**Present:** N/A

**Goals:** Record expenses incurred throughout the semester

**Content:**

## Materials and expenses

| Item | Description | Manufac-turer | Mft Pt# | Vendor | Vendor Cat# | Date | # | Cost Each | Total | Link |
|---|---|---|---|---|---|---|---|---|---|---|
| **Category 1** | | | | | | | | | | |
| | 3D Printed CEVIK & 5 KSMs | N/A (3D Printed) | N/A | N/A | N/A | 09/19 | 1 | | $3.48 | |
| | 3D Printed CEVIC and 8 KSMs | | | | | 10/20 | 1 | | $12.60 | |
| | 3D Printed CEVIC and gear | | | | | 11/10 | 7 | | $7.63 | |
| | 3D Printed 10 IRE gears for testing samples | | | | | 11/18 | | | $12.65 | |
| | 3D printed connector for CEVIC and Servo Motor | | | | | 11/20 | | | $0.14 | |
| **Category 2** | | | | | | | | | | |
| | Purchase makerspace Servo | Smraza | | | | 10/24 | 2 | | $5.28 | |
| | PLA 3D printing Rotational Element | | | | | | 3 | | $0.27 | |
| | Additional Gear | | | | | | 3 | | $0.15 | |
| | Makerspace 3D printed | | | | | 10/24 | 1 | | $1.83 | |
| | | | | | | | | **TOTAL:** | **$44.20** | |

**Conclusions/action items:**

Seek reimbursement for expenses not charged to BME funding account

# Cytotoxicity Testing Protocol

SOPHIA SPEECE - Dec 09, 2025, 4:57 PM CST

**Title: Protocol - Cytotoxicity Testing**

**Date:** 12/9/2025

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Develop and record protocol for cytotoxicity testing

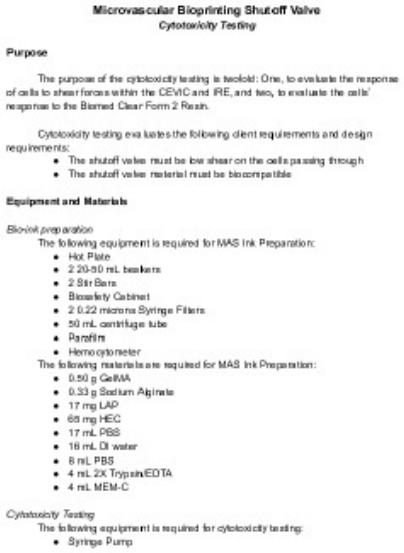
**Content:**

See attachment below

**Conclusions/action items:**

Cytotoxicity testing was unable to be completed due to contamination in the incubator that killed the cells.

SOPHIA SPEECE - Dec 09, 2025, 4:58 PM CST



**Microvascular Bioprinting Shutoff Valve**
*Cytotoxicity Testing*

**Purpose**

The purpose of the cytotoxicity testing is twofold: One, to evaluate the response of cells to shear forces within the CEVIC and IRE, and two, to evaluate the cells' response to the Biomed Clear Form 2 Resin.

Cytotoxicity testing evaluates the following client requirements and design requirements:

- The shutoff valve must be low shear on the cells passing through
- The shutoff valve material must be biocompatible

**Equipment and Materials**

*Bio-ink preparation*

The following equipment is required for MAS Ink Preparation:

- Hot Plate
- 2 20-50 mL beakers
- 2 Stir Bars
- Biosafety Cabinet
- 2 0.22 micron Syringe Filters
- 50 mL centrifuge tube
- Parafilm
- Hemocytometer

The following materials are required for MAS Ink Preparation:

- 0.50 g GelMA
- 0.30 g Sodium Alginate
- 17 mg LAP
- 68 mg HEC
- 17 mL PBS
- 16 mL DI water
- 8 mL PBS
- 4 mL 2X Trypsin/EDTA
- 4 mL MEM-C

*Cytotoxicity Testing*

The following equipment is required for cytotoxicity testing:

- Syringe Pump

Download

**Cytotoxicity_Testing.pdf (102 kB)**

# Durability Testing Protocol

SOPHIA SPEECE - Dec 09, 2025, 5:01 PM CST

**Title: Protocol - Durability Testing**

**Date:** 12/9/2025

**Content by:** Sophia Speece, Steph Vigmond

**Present:** N/A

**Goals:** Create and record a protocol for durability testing of the IRE

**Content:**

See below

**Conclusions/action items:**

Testing resulted in some scratches on the surfaces of the IREs, but no significant damage that would effect the function of the device.

SOPHIA SPEECE - Dec 09, 2025, 5:01 PM CST

**Microvascular Bioprinting Shutoff Valve**
**Durability Testing**

**Purpose**

The purpose of this testing is to evaluate the durability of the Integrated Rotary Element (IRE) and therefore the life in service. It verifies that the strength and functionality of the IRE do not diminish with repeated use. The test will first run five samples through a simulated life in service of one hundred cycles to and from 180°. These five samples will be visually inspected for wear/cracks/etc. Then, the five test samples and five control samples will be loaded onto the MTS testing machine and compressed until failure. The samples will pass if there is no statistically significant difference between the test samples and the controls, and if there is minimal visible damage to the IREs.

Durability testing evaluates the following client specifications and product specifications:

- Life in service: The device must be able to operate for five minutes per hydrogel sheet and print multiple hydrogels per hour

**Equipment and Materials**

This test uses the following equipment:

- MTS Universal Testing Machine
- 10 kN Load Cell

This test uses the following materials:

- CEVIC and IRE
- Servo motor
- CEVIC-Servo connector
- Breadboard
- Arduino
- Standard wires

**Procedure**

*Setup*

1. Label each of the ten test samples with a unique number/color. Avoid the center of the IRE as the label may be scraped off during testing. Label five of them as test samples and five of them as control samples.

Download

**Durability_Testing.pdf (592 kB)**

# Functionality Testing Protocol

SOPHIA SPEECE - Dec 09, 2025, 5:06 PM CST

**Title: Protocol - Functionality Testing**

**Date:** 12/9/2025

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Develop and record a test for the functionality of the IRE device, specifically assessing if hydrogel can flow through or is stopped when closed

**Content:**

See attachment below

**Conclusions/action items:**

Further functionality testing will be needed once the team has the rotary valve to switch KSM inputs. This functionality testing assessed if hydrogel can flow through one KSM, the IRE, and the CEVIC.

Some issues with leaking, potential design solutions include elastic material and a locking pin

SOPHIA SPEECE - Dec 09, 2025, 5:06 PM CST

**Microvascular Bioprinting Shutoff Valve**
**Functionality Testing**

**Purpose**

The purpose of this testing is to evaluate the functionality of the complete assembled Shutoff Valve. This test simulates printing a hydrogel using manual syringe methods and dyed gelatin rather than the 3D Bioprinter and the GelMa and HEC hydrogels.

Functionality testing evaluates the following client specifications and product specifications:

- 

**Equipment and Materials**

This test uses the following equipment:

- Hot plate
- 2x 50 mL beaker
- 2x stir bars
- 2x weight boats
- Graduated cylinder
- CEVIC-Servo complex
- Up to 6 Kenics Static Mixers (KSMs)
- 2x 20mL Syringes

This test using the following materials:

- 2 food dyes of contrasting colors
- Gelatin
- DI Water

**Procedure**

*Gelatin Preparation*

1. Acquire all materials
2. Measure 20 mL of DI water using a graduated cylinder, then pour into 50 mL beaker
3. Repeat step two for the second beaker
4. Measure out 4 grams of gelatin (2 g per beaker), then add to the beakers. Swirl gently to mix
5. Let gelatin bloom in the cool water for 5-10 minutes

Download

**Functionality_Testing.pdf (72.2 kB)**

# Hydrogel Fabrication Protocols

SOPHIA SPEECE - Dec 15, 2025, 8:08 PM CST

**Title: Hydrogel Fabrication Protocols**

**Date:** Entered 12/15/2025

**Content by:** Sophie Speece

**Present:** N/A

**Goals:** Use these protocols to inform the writing of the team's cytotoxicity protocols

**Content:**

Hydrogel fabrication protocols provided by Josh Alexander. See attached files below

**Conclusions/action items:**

Use these protocols to write the team's cytotoxicity protocols

SOPHIA SPEECE - Dec 15, 2025, 8:10 PM CST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**MAS_Ink_Preparation_Benchling_1_.pdf (61.1 kB)**

SOPHIA SPEECE - Dec 15, 2025, 8:10 PM CST

Procedure

MAS Ink Preparation

Chaotic Printing

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**MAS_Chaotic_Printing_Benchling_1_.pdf (47.3 kB)**

**Electronics Testing**

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 15, 2025, 9:57 PM CST

# Circuitry Testing Protocols

Date: 19 Nov 2025

Content by: Dominique , Ana, Mahathi

Present: Ana, Dominique, and Mahathi

Goals: Update the circuit testing protocol for 20 November 2025 testing.

### Test 1: Alignment Drift Over Cycles

Objective: Measure the number of cycles (displacement from 1 KSM to the other is a cycle) it takes for the IRE hole to misalign and realign

Parameters: Determine pulse width corresponding to 60° rotation

Hypothesis: Expected pulse width: 1.5 ms high from 1-2 ms neutral range.

- Assess how many cycles until first signs of misalignment occur
- Determine # of cycles until normal displacement is achieved (indicating reset).
- Validate expected pulse width modulation (PWM) for precise 60° rotation (e.g., 50 Hz signal, 1.5 ms pulse ≈ 60° from neutral).
- Record number of cycles to **50% misalignment**

### Test 2: Mechanical Displacement Measurement

Purpose: Confirm IRE rotates to the appropriate degrees consistent with arduino code (target: 60° ±2°). Using a protractor, but hopefully can acquire force sensors later for more accurate data and to calculate torque. Quantify torque via arm displacement and load.

Steps:

1. Run standard Arduino code.
2. Attach Servo Motor Gear to the IRE; measure the angular displacement with digital protractor (target: 60° ±2°).
3. Repeat for 10+ cycles, logging delay periods where rotation occurs

Key Observations:

- IRE reaches 50% non-alignment after ~10 prongs (3 KSM rotations, traveled 3 KSM distances over 3 trials).

Updated Recommendations for 20 Nov:

- Integrate force-torque sensor (e.g., HX711 load cell)
- refine PWM to 1.45-1.55 ms for 60°,

- Perform more cycles with 30 ms delays.
- Estimate velocity to travel from 1 KSM to the other

# Printing 10/3

DOMINIQUE GOODEN (degooden@wisc.edu) - Oct 03, 2025, 4:26 PM CDT

Date: 5 October 2025

Present: Mahathi, Steph, Dominique, Sophie

Content by: Dominique

Aim: Print hydrogel and visualize pattern with client's KSM and our KSM.

Parameters:

2 syringes: one containing 10 mL GelMA and the other containing 10 mL HEC fugitive ink (both preheated at 65*C ???)

Flow rate: 1.5 mL/min.

Two tubes (for each respective input) attached to KSM tube holders. Remove air bubble first. Print in a steady line. Once printed, spray with 8% CaCl2. Once sprayed, use UV lamp to fully crosslink and cure the hydrogel for 60 seconds.

Results:

Client's KSM: Two hydrogels were printed. In one hydrogel, HEC, GelMA, HEC (total of 3 channels were observed). In the second hydrogel, only two channels (1 HEC, 1 GelMA) were seen.

Team's KSM: The team printed several hydrogels. The team observed some channel patterns.

Clients Notes: Consider temperature, material stiffness (more crosslinking/UV), angle of KSM (we are not sure what is an optimal KSM angle for printing accurately).

Future steps:

Sub teams will meet later this month to develop approaches. Mahathi identified some valves that work with a LABVIEW setup. The CFD team discussed appropriate software to use for analysis.

Future plans can focus on printing KSMs with distinct angle and performing print procedures to identify optimal printing angle. This knowledge can then guide future design so we can print a valve that can accommodate an appropriate KSM angle.

# Durability Testing

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:31 PM CST

**Title: Durability Testing**

**Date:** 11.25.25

**Content by:** Sophie Speece, Steph

**Present:** Sophie Speece, Steph Vigmond

**Goals:** Complete durability testing to evaluate the strength of the IREs

**Content:**

See durability testing protocol page for information on how the test was executed

- Hard to make flush while ensuring it can still rotate
- Wearing down gears over time would be good to measure, but difficult to tell when it occurs because that would require much more extensive testing.
- Dr. Wille suggested some testing and quantification we could try - wear down on gear teeth, using ImageJ to quantify the wear on the surface, can still do 3 point bending to see if it has weakened
- Seems to be issue with motor overheating, so have to give it plenty of time between replicates (also not run motor continuously when actually using device, there will be more breaks)
- Noticed some small pieces of material on table after testing indicating wearing, but not too significant.
- Have to count to 100 reps because the code does not stop it there, that is ok

**Conclusions/action items:**

- *Note - for tests 2-5, "top" was always the side the numbers were written on, and that was facing up during testing for easily comparable results

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:20 PM CST

Download

**IRE_test_5_bottom.jpeg (4.11 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:20 PM CST

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**IRE_test_5_top.jpeg (3.63 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:20 PM CST

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**IRE_test_4_bottom.jpeg (3.83 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:20 PM CST

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**IRE_test_4_top.jpeg (3.95 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_3_bottom.jpeg (3.73 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_3_top.jpeg (3.61 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_2_bottom.jpeg (3.55 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_2_top.jpeg (3.62 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_1_bottom.jpeg (3.59 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_test_1_top.jpeg (3.77 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_baseline_2.jpeg (3.52 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 25, 2025, 9:21 PM CST

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**IRE_baseline_1.jpeg (3.59 MB)**

# Oct 30 Servo Sweep Starter Code

SOPHIA SPEECE - Oct 29, 2025, 7:55 PM CDT

**Title: Servo Sweep Starter Code**

**Date:** 10.30.2025

**Content by:** Sophie Speece

**Present:** Sophie, Steph

**Goals:** Utilize the starter code to program our servo motor-IRE

**Content:**

```
/* Sweep
 by BARRAGAN <http://barraganstudio.com>
 This example code is in the public domain.

 modified 8 Nov 2013
 by Scott Fitzgerald
 https://www.arduino.cc/en/Tutorial/LibraryExamples/Sweep
*/

#include <Servo.h>

Servo myservo;  // create servo object to control a servo
// twelve servo objects can be created on most boards

int pos = 0;    // variable to store the servo position

void setup() {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}

void loop() {
  for (pos = 0; pos <= 180; pos += 1) { // goes from 0 degrees to 180 degrees
    // in steps of 1 degree
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15 ms for the servo to reach the position
  }
  for (pos = 180; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15 ms for the servo to reach the position
  }
}
```

**Conclusions/action items:**

change to rotate 60 degrees 6 times from 0 to 360, and then in reverse

# CEVIC and Integrated Rotary Element - All Current Files

SOPHIA SPEECE - Dec 15, 2025, 7:52 PM CST

**Title: CEVIC and Integrated Rotary Element - All Current Files**

**Date:** 12/15/2025

**Content by:** Sophie Speece, Steph Vigmond

**Present:** N/A

**Goals:** This page contains the most recent iterations of the CEVIC and IRE as of the final week of Fall 2025 Semester

**Content:**

See attached SolidWorks and .stl files below

Included is the IRE, the two CEVIC halves, the CEVIC-Servo holder, and a Servo motor Solidworks file (see reference below)

[1] "Standard Size Servo 3D Model (STP) by Ludvig Broomé | Download free STL model," Printables.com. Accessed: Dec. 15, 2025. [Online]. Available: https://www.printables.com/model/360150-standard-size-servo-3d-model-stp

**Conclusions/action items:**

Use these files to iterate and build upon in second semester

SOPHIA SPEECE - Dec 15, 2025, 7:50 PM CST

Download

**AssemGearIRE.SLDPRT (576 kB)**

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**AssemGearIRE.STL (217 kB)**

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**BottomHalfwithpin.SLDPRT (367 kB)**

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**BottomHalfwithpin.STL (814 kB)**

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**CEVIC_Servo_connector_2.SLDPRT (114 kB)**

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**CEVIC_Servo_connector_2.STL (14.5 kB)**

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**Standard-Servo.stp.SLDPRT (384 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:50 PM CST


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**TopHalfwpinhole.SLDPRT (271 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:50 PM CST


Download

**TopHalfwpinhole.STL (277 kB)**

# Old 3D Files

SOPHIA SPEECE - Dec 15, 2025, 7:55 PM CST

**Title: Old 3D Files**

**Date:** 12/15/2025

**Content by:** Sophie Speece, Steph Vigmond

**Present:** N/A

**Goals:** This document contains all previous iterations of the final 3D files included in notebook page "CEVIC and Integrated Rotary Element - All Current Files"

**Content:**

See the attached files below

**Conclusions/action items:**

These files should be stored in case they are needed for modifications to the design in the future

SOPHIA SPEECE - Dec 15, 2025, 7:57 PM CST

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**11_4_TopHalfwpinholeTIGHT.SLDPRT (295 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:57 PM CST

Download

**11_4_TopHalfwpinholeTIGHT.STL (277 kB)**

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**AssemGearIRE_-_bald_ire-1.STL (50.6 kB)**

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**AssemGearIRE_-_gear_ring_3-1.STL (166 kB)**

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**bald_ire.SLDPRT (122 kB)**

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Download

**BottomHalf.SLDPRT (341 kB)**

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Download

**CEVIC_bottom_half_combined.stl (14.2 MB)**

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**CEVIC_bottom_half.stl (14.2 MB)**

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**CEVIC_Servo_connector_2.STL (14.5 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:57 PM CST


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**CEVIC_Servo_connector_SLIM.SLDPRT (132 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:57 PM CST

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**CEVIC_Servo_connector_SLIM.STL (27.9 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:57 PM CST

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**CEVIC_Servo_connector.SLDPRT (99.6 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:58 PM CST

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**CEVIC_Servo_connector.STL (15.7 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:58 PM CST

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**CEVIC_Sheet_EG_.SLDPRT (4.77 MB)**

SOPHIA SPEECE - Dec 15, 2025, 7:58 PM CST

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**CEVIC_Sheet_EG_.stl (3.9 MB)**

SOPHIA SPEECE - Dec 15, 2025, 7:58 PM CST

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**gear_ring_2.SLDPRT (543 kB)**

SOPHIA SPEECE - Dec 15, 2025, 7:58 PM CST

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**gear_ring_3.SLDPRT (588 kB)**

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**gear_ring.SLDPRT (415 kB)**

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**IRE_80_teeth.SLDPRT (285 kB)**

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**IRE_80_teeth.STL (86.5 kB)**

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**IRE_80_teethwithpinhole_moved_hole.SLDPRT (341 kB)**

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**IRE_80_teethwithpinhole.SLDPRT (347 kB)**

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**Part_Studio_1_-_Exit_Nozzle.sldprt (406 kB)**

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**TopHalf.SLDPRT (235 kB)**

# Preliminary Presentation

SOPHIA SPEECE - Dec 15, 2025, 8:02 PM CST

**Title: Microvascular Bioprinting Shutoff Valve - Preliminary Presentation**

**Date:** Entered 12/15/2025, Presentation on 10/03/2025

**Content by:** Team

**Present:** Team

**Goals:** Present three preliminary designs and their rankings using a design matrix for a described problem for a client

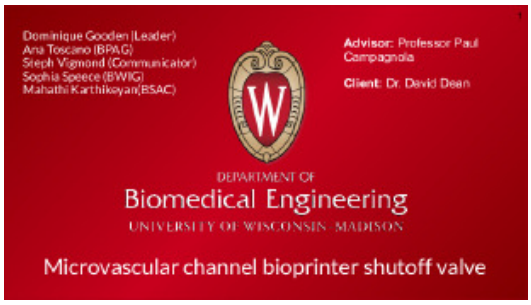
**Content:**

See attachment below

**Conclusions/action items:**

Continue writing preliminary report, decide on which of the three designs to move forward with.

SOPHIA SPEECE - Dec 15, 2025, 8:03 PM CST




Download

**Microvascular_Shutoff_Valve_Preliminary_Presentation_2_.pdf (2.42 MB)**

# Preliminary Report

SOPHIA SPEECE - Dec 15, 2025, 8:05 PM CST

**Title: Microvascular Bioprinting Shutoff Valve - Preliminary Report**

**Date:** Entered 12/15/2025, submitted 10/06/2025

**Content by:** Team

**Present:** Team

**Goals:** Present the team's understanding of the client's challenge and three solution ideas

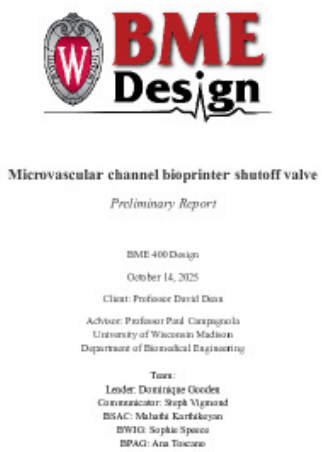
**Content:**

See attachment below

**Conclusions/action items:**

Begin prototyping and fabrication planning

SOPHIA SPEECE - Dec 15, 2025, 8:05 PM CST



Microvascular channel bioprinter shutoff valve

*Preliminary Report*

BME 400 Design

October 14, 2025

Client: Professor David Dean

Advisor: Professor Paul Campagnola
University of Wisconsin Madison
Department of Biomedical Engineering

Team:
Leader: Dominique Gooden
Communicator: Steph Vigmond
BSAC: Mahathi Karthikeyan
BWIG: Sophia Speece
BPAG: Ara Toscano

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**Preliminary_Report.pdf (3.11 MB)**

# Product Design Specifications

SOPHIA SPEECE - Dec 15, 2025, 8:15 PM CST

**Title: Microvascular Bioprinting Shutoff Valve Product Design Specifications (PDS)**

**Date:** Entered 12/15/2025, submitted 09/19/2025

**Content by:** Team

**Present:** Team

**Goals:** Turn the client requirements into tangible quantitative product design specifications

**Content:**

See attachment below

**Conclusions/action items:**

Use these criteria to brainstorm potential solutions to the client problem

SOPHIA SPEECE - Dec 15, 2025, 8:16 PM CST


BME Design

Microvascular channel bioprinter shutoff valve

*Product Design Specifications*

BME 400 Design

September 18, 2025

Client: Prof. David Dean

Advisor: Prof. Paul Campagnola
University of Wisconsin Madison
Department of Biomedical Engineering

Team:
Leader: Dominique Gooden
Communicator: Steph Vigneond
BSAC: Mahathi Karthikeyan
BWIG: Sophie Speece
BPAG: Ana Toscano

Download

**PDS.pdf (323 kB)**

# Final Poster

SOPHIA SPEECE - Dec 15, 2025, 8:21 PM CST

**Title: Microvascular Bioprinting Shutoff Valve - Final Poster Presentation**

**Date:** Entered 12/15/2025, presented on 12/05/2025

**Content by:** Team

**Present:** Team

**Goals:** Present the team's semester of research and final prototype at the BME Design poster session

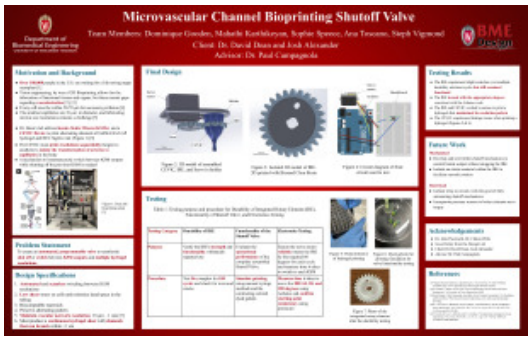
**Content:**

See attached file below

**Conclusions/action items:**

Complete final paper

SOPHIA SPEECE - Dec 15, 2025, 8:22 PM CST

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**BME_400_Poster_Presentation.pdf (2.05 MB)**

# New PageSheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

DOMINIQUE GOODEN (degooden@wisc.edu) - Sep 12, 2025, 6:37 PM CDT

Entry By: Dominique

Goal: Understand the client's past work and how it informs our project

Contents:

1. Bioprinting is a novel method to construct highly detailed vascularized structures. Electrospinning, casting, and molding are also methods that are used in tandem with bioprinting.

2. The client has a patent pending for their CEVIC device that aims to print large, complex microvascular structures using hydrogel sheets. The device allows the user to have control over the material composition and the structural morphology, which is aided by kenics static mixers.Cells are later added.

DOMINIQUE GOODEN (degooden@wisc.edu) - Sep 24, 2025, 6:00 PM CDT

Continuation:

**Title:**

**Date:** 9.24.25

**Content by:** Dominique

**Goal: Understand more about client's previous device design**

**Content:**

**-The CEVIC device extrudes hydrogel sheets with internal microchannels. Through chaotic printing, the KSMs striate the bioink and fugitive material to streamline patterns for the hydrogel sheets. These can be used to replicate a vast array of microvasculature.**

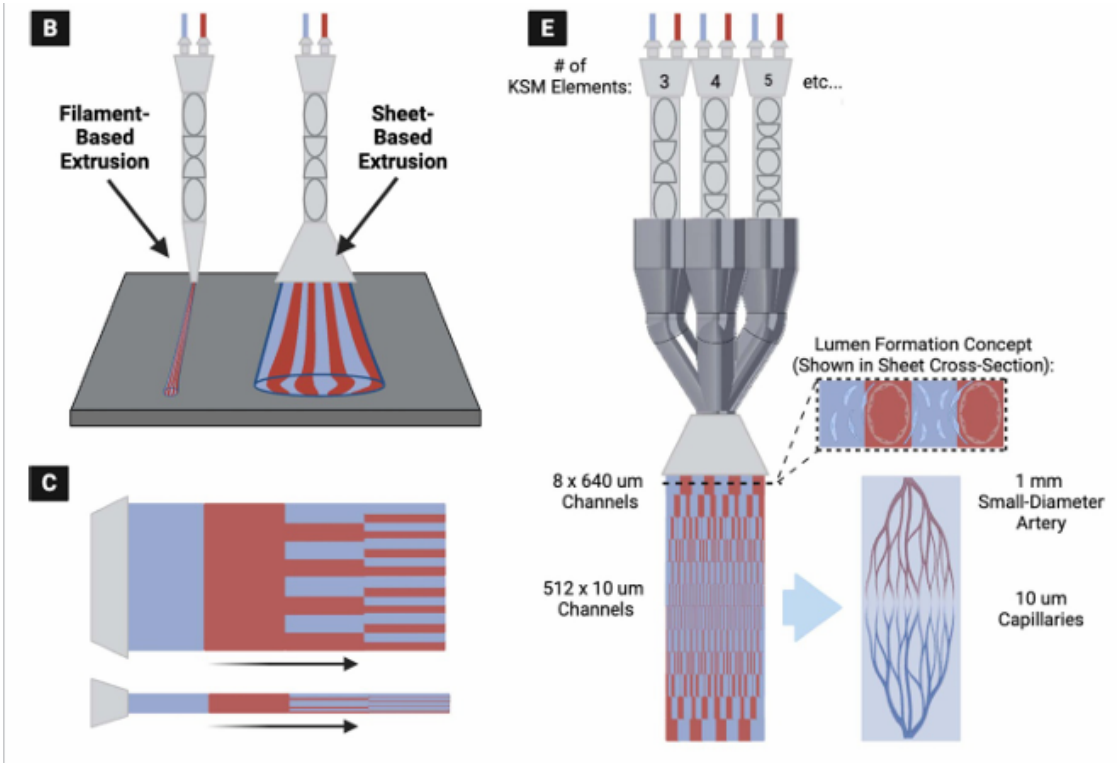
**Components:**

**- Syringes (one for bioink, other for fugitive)**

*** The fugitive would ideally serve as a biocompatible channel for blood to flow through and to study cell-tissue interactions.**

**- Syringe pump: apparatus to facilitate fluid output. Very important for controlling volumetric rates.**

-**KSM: mix the fluids together into striated patterns for desired channels. # of striations is correlated to channel thickness (important for computational fluid dynamics studies later on).**




**Note how there are 2 fluid inputs from syringes attached to KSM. Tubing is attached to maintain watertight seal.**

**- Fanning Nozzle Output: Varies in width; main goal is to print the hydrogel into thin sheets while preserving the striated fluid patterns. Can vary in diameter depending on application.**

**-Valves**

- *** Static valve: Holds the KSMs in place.**
- *** Mechanical valves: Control which KSM receives the input.**

Structure/Flow of Operations:

**-The syringes are prefilled with fluid and are connected to KSMs. The ink coats the KSMs to clear out residual air. Towards the end, valves regulate which fluid input is for its corresponding KSM.**

**Total timeline - 5 min.**

**-After extrusion, the hydrogel sheets cure via UV light or a sodium alginate spray.**

**Project Objective:**

**- Need to develop a way to automate switching between fluids and KSMs.**

**Lingering Questions:**

**1. What is the purpose of the mechanical valves between ink inputs and KSMs prior to mixing? are they just holding the tubing in place? or do they add any value to the design?**

**2. Would client be open to printing multiple hydrogels with multiple sheets at once? Or is their preferred process printing one hydrogel with multiple thin sheets?**

# Continuous chaotic bioprinting of skeletal muscle-like constructs

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 7:06 PM CST

**Title:** Continuous chaotic bioprinting of skeletal muscle-like constructs

**Date:** October 19th, 2025

**Content by: Dominique**

**Goals:** Understand chaotic bioprinting applications and parameters we might want to consider for testing

source:

Edna Johana Bolívar-Monsalve, Carlos Fernando Ceballos-González, Karen Ixchel Borrayo-Montaño, Diego Alonso Quevedo-Moreno, Juan Felipe Yee-de León, Ali Khademhosseini, Paul S. Weiss, Mario Moisés Alvarez, Grissel Trujillo-de Santiago,

Continuous chaotic bioprinting of skeletal muscle-like constructs,

Bioprinting,

Volume 21,

2021,

e00125,

ISSN 2405-8866,

https://doi.org/10.1016/j.bprint.2020.e00125.

**Content:**

Chaotic bioprinting is an extrusion based method that generates chaotic flows to form highly detailed constructs in an optimized reproducible manner. The authors utilized chaotic bioprinting to form muscle tissue constructs that mimic native skeletal muscle. They incorporated the use of kenics static mixers (KSMs) to print multi-layered filaments (130um thick, 1.2mm wide) of myoblast-laden GelMA and alginate. The printed microarchitecture is intended to resemble fasicles which are bundled by muscle fibers.

The bioprinting system setup to achieve the muscle constructs consisted of 3 KSMs with syringes extruding flow at 1.5mL/min. The nozzle outlet was submerged in 2% CaCl2 solution at 8 degrees Celsius, so when the bioink deposited, it immediately crosslinked. The constructs were then placed in DPBS and were crosslinked with UV light at 365 nm for 30seconds. Post printing,m the constructs were cultured in 3mL of DMEM/high glucose (10% FBS, 1% penicillin-streptomycin).

CFD studies were performed and incorporated a multiphase model. This model intends to approximate fluid output through the bioprinting system. A surface tension coefficient also modeled fluid:fluid forces, and navier stokes equations for laminar flow were utilized for transient states. The simulation involved no slip boundaryconditions.

Results: Cells demonstrated a >85% post print viability immediately after and even extending to 4 weeks post-extrusion. More broadly, this study demonstrates how with the right bioinks and parameters, continuous chaotic printing can enhance the viability of bioprinted constructs.

Next steps: The workflow in this paper mirrors a lot of the team’s hydrogel extrusion strategies, especially with the crosslinking and usage of GelMAwith cell seeding. The paper provides useful information of factors considered in the bioprinting process that the team can benefit from learning.

# An overview of extrusion-based bioprinting with a focus on induced shear stress and its effect on cell viability

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 7:08 PM CST

**Title:**

# An overview of extrusion-based bioprinting with a focus on induced shear stress and its effect on cell viability

**Date:** November 12, 2025

**Content by: Dominique**

**Goals:** Understand how shear stress impacts cell viability and ways to maximize cell viability

Source:

Selwa Boularaoui, Ghada Al Hussein, Kamran A. Khan, Nicolas Christoforou, Cesare Stefanini,

An overview of extrusion-based bioprinting with a focus on induced shear stress and its effect on cell viability,

Bioprinting,

Volume 20,

2020,

e00093,

ISSN 2405-8866,

https://doi.org/10.1016/j.bprint.2020.e00093.

(https://www.sciencedirect.com/science/article/pii/S2405886620300208)

**Content:**

3D bioprinting is an increasingly relevant fabrication technique for small-scale tissue engineering. The goal of 3D bioprinting is to produce biomaterial constructs that can be seeded with cells. However, during the bioprinting, the cells experience mechanotransduction, impacting their viability. As a matter of fact, shear stress is the primary attributor to cell damage.

The review article highlights how mechanotransduction begins at the cell surface proteins. The cells sense environmental changes and initiate cell transduction signaling pathways in response to mechanotransduction. Different outcomes as a result of the external changes, and these include cell death, altered behavior, or cell differentiation.

The review article also highlights the importance of choosing bioinks with shear thinning properties to minimize cell shear stress. Additionally, parameters such as the nozzle diameter, printing speed and temperature also contribute to the cell viability. If the nozzle diameter is too small, there is a higher velocity gradient which increases shear stress on cells. Additionally, ong printing times as well as excessively high temperatures could induce further shear stress and denature. Mathematical models are currently being developed to predict cell viability and damage early on, as well as informing appropriate printing constraints.

$$I(\%) = Ct^{a}\tau^{b}$$

The review article highlights many suggestions for improving cell viability. To address long bioprinting durations, the authors suggest implementing hybrid polymer constructs in the bioink to decrease cell damage. However, there must be a careful balance of appropriate biomaterial, as it was found taht for concentrated bioinks, more dead cells were associated with higher alginate concentrations. Additionally, utilizing tapered nozzle designs is believed to reduce the stresses that cells experience.

Next steps: Given that there were issues obtaining cells this fall semester, the team will test cell viability next semester. This article will provide useful insight for analyzing results later on.

# An experimental workflow for bioprinting optimization: Application to a custom-made biomaterial ink

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 10:54 PM CST

**Title:** An experimental workflow for bioprinting optimization: Application to a custom-made biomaterial ink

**Date:** 14 December 2025

**Content by: Dominique**

Source:

Pablo Martín Compaired, Elena García-Gareta, María Ángeles Pérez. An experimental workflow for bioprinting optimization: Application to a custom-made biomaterial ink. *International Journal of Bioprinting* 2025, 11(3), 397–415. https://doi.org/10.36922/IJB025120094

**Goals:** Learn about various metrics utilized to evaluate the quality of bio printed constructs

**Content:**

Summary: This article evaluates 3 properties: extrusion, filament deposition, and printability, to address quality control concerns with printing bioink. The goal would be to gain data that informs appropriate pressures and printing speeds for high quality extrusion.

The bioink utilized consists of 10% w/v gelatin methacryloyl (GelMA, Bloom 300, 60% DoS), 2% w/v lyophilized egg white protein, and 0.5% w/v LAP photoinitiator, prepared by mixing temperature-controlled solutions for shear-thinning extrusion and UV crosslinking.

The first metric they evaluate is extrudability, which traditionally evaluates the hydrogel output at the nozzle. However, the authors point out accuracy challenges in volume and density outputs due to the crosslinking. They propose quantifying the bioink deposition rate for variable printing conditions. This would help determine the optimal equipment settings for reliable extrusion.

The second metric they evaluate is filament diameter optimization. It is established that at constant printing pressures, increasing the printing speed reduces the total deposited material. Increasing the printing pressure leads to more deposited material while decreasing the printing pressure leads to less deposited material. It is important to strike the right balance between an ideal printing pressure and speed to maintain quality prints.

The authors mention that previous studies that have evaluated filament uniformity only utilized a portion of the material output to assess this metric. So the study team implemented a deposition test to print a monolayer and image them. The entire filament diameters were measured for a more accurate estimate. They then constructed a series of equations to evaluate the largest geometric dimensions located on the output material.

minimum radius can still fit. It is defined

$$L_{Th}(x) = \max_{r \in \mathbb{R}} \{ (L_s \oplus C(r))(x) \} \qquad L_S = \begin{cases} D(x), \text{ if } D(x) \geq r \\ 0 \quad \text{otherwise} \end{cases}$$

The final metric they evaluate is printability. More specifically, this metric assesses the structural integrity of the output.  They developed a Python script to quantify printability. This equation factors in the enclosure pore circularity (C_), the pore surface area (S), and the pore diameter (P)

$$Pr = C_{id}\left(\frac{1}{C_{re}}\right) = \frac{\pi}{4}\frac{1}{C} = \frac{P^2}{16S}$$

**Table 1. Printing parameters for 3D bioprinting tests**

| Printing parameters | Value |
|---|---|
| Nozzle type | Tapered tip (standard) |
| Nozzle diameter (mm) | 0.41 |
| Hotbed temperature (°C) | 10 |
| Printing temperature (°C) | 24 |
| Printing pressure (kPa) | 0–100 (E); 70–80 (D, P) |
| Printing speed (mm/min) | 300–900 (D, P) |
| Retraction speed (mm/min) | 4800 (E, D, P) |
| Layer height (mm) | 1 (E); 0.4 (D, P) |

Abbreviations: D, deposition; E, extrudability; P, printability.

Results: 75 kPa at 600 mm/min speeds were the ideal determined pressures and biprinting speeds for consistent 3D fidelity and extrusion.

Action items/next steps:
-Inquire about extrusion speeds and pressures
-Brainstorm what metrics can be incorporated into our testing

# CFD Bioprinting

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 10:56 PM CST

**Title:** Computational Fluid Dynamics (CFD) Analysis of Bioprinting

**Date:** 3 October 2025

**Content by: Dominique**

Source:
Fareez UNM, Naqvi SAA, Mahmud M, Temirel M. Computational Fluid Dynamics (CFD) Analysis of Bioprinting. *Adv Healthc Mater*. 2024;13(20):e2400643. doi:10.1002/adhm.202400643

**Goals:** Learn about CFD applications in bioprinting with the goal of enhancing knowledge and parameters of team's current CFD simulations

**Content:**

Summary: This is a review article that overviews computational fluid dynamics (CFD) for bioprinting applications.

CFD is a subsector of fluid dynamics for numerical analysis and software modeling of fluid simulations. CFD is utilized for various types of bioprinting, such as extrusion based, droplet based, and laser based bioprinting. CFD gathers metrics including but not limited to nozzle speed, shear stress, printability, and cell viability. CFD combines these factors into equations that can be used to model fluid simulations, flow, and deformation. Below is a table of various CFD softwares used for bioprinting.

Table 1. Summary of CFD software's for bioprinting.

| Name | Purpose | Type of bioprinting method | Studied rheological properties | Reference |
|---|---|---|---|---|
| IPS IBOFlow | To simulate the flow behavior of the bioink and predict the final shape | Extrusion | Viscosity, flow rate, pressure | [63] |
| COMSOL Multiphysics/COMSOL 4.0a | To study the diffusion in scaffold design and how the pore structure affects it | Extrusion | Effective diffusivity | [64] |
| | | Droplet | Flow rate, viscosity, density | [69] |
| COMSOL Multiphysics 4.2 | To simulate the flow in the microfluidic channel | Extrusion | Viscosity, shear stress | [70] |
| COMSOL Multiphysics 5.2a | To investigate the effect of shear stresses in the printing geometry (conical/straight nozzles) and the cell viability | Extrusion | Process-induced shear and extensional stress | [71] |
| | | Extrusion | | [72] |
| | Simulate fluid flow inside the needle on the printing profile to investigate velocity field and mass flow rate | Extrusion | Shear stress, pressure, temperature, velocity | [73] |
| | | Droplet | | [74] |
| | To examine the flow of non-crosslinked gelatin in the needle | Droplet | Shear stress, viscosity, pressure, concentration | [75] |
| | To identify the shear stresses and pressure drop that cells experience in the bioprinting process | Droplet | | [76] |
| | To improve drug transport in the intraperitoneal region during peritoneal metastasis | | Shear stress, pressure, viscosity, flow rate | |
| | To study the 3D matrix profile at the bottom channel and the top channel | | Pressure, concentration, solid stress | |
| | Devising a mathematical model to simulate the mass and momentum transport in the microfluidic device | | Concentration, mass flow rate, momentum | |
| ANSYS Workbench/ANSYS Fluent/ANSYS CFX | To examine the maximum wall shear stress in three different nozzle designs: tapered conical, conical, and cylindrical | Extrusion | WSS, mass flow rate | [12] |
| | | Extrusion | Viscosity, storage modulus, loss modulus, shear stress, flow rate | [77] |
| | | Extrusion | | [78] |
| | To study the wall shear stress in conical and straight-shaped nozzle | Extrusion | Shear stress, concentration | [79] |
| | | Droplet | Shear stress, pressure, velocity, shear rate, dynamic viscosity, mass flow rate | [80] |
| | To simulate the flow hemodynamics in pulmonary artery geometries | Extrusion | | [81] |
| | | Scaffold-free | | [82] |
| | To identify the pressure gradient and maximum shear stress at the top of the nozzle to verify analytical calculations | Laser | Shear stress, velocity, viscosity | [83] |
| | | Laser | Shear stress, porosity | [84] |
| | To study the effect of shear stress in piezoelectric print-head used in drop-on-demand (DoD) bioprinting method | | Force, pressure, shear stress, flow rate, oxygen distribution | |
| | To investigate porosity in scaffolds and the relationship between pore structure and scaffold maximum shear stress | | Velocity, shear stress | |
| | To improve tissue design and bioreactor implementation | | Velocity, length of jet, mass flow rate, droplet size | |
| | To analyze flow in a recanalized model of aortopulmonary collateral arteries that are affected by Teuralogy of Fallot | | | |
| | To assess the growth and development of flow and the outcome of printing, that is, the printing quality | | | |
| FLOW 3D | To study droplet formation in inkjet printing modality | Droplet | Density, viscosity, surface tension, velocity | [85] |
| OpenFOAM | To optimize nozzle design and identify all major printing factors that affect the printing process | Extrusion | Shear stress | [68] |
| | | Extrusion | Shear stress, porosity, surface roughness | [86] |
| | To investigate the effect of shear stress prevention methods to improve cell viability | Extrusion | | [13] |
| | To investigate the flow in the printer head and the deposition to identify the relationship between printing parameters and hydrogel behavior | | Viscosity, flow rate, pressure, shear stress | |

(Continued)

Next, I will discuss CFD applications for extrusion based bioprinting. Extrusion-based bioprinting builds layered 3D filaments through a nozzle output with the hope of modeling vascularized tissue networks and scaffolds. Due to the significant level of detail required to achieve such networks, filament morphology is very important and it influences the final print quality. CFD applications utilize the bioink material properties to design nozzles that aid its printing quality so that the hydrogels can be seeded with cells later on.

Different CFD softwares have slightly different processing steps for achieving simulations. But the picture below depicts the ANSYS/Fluent workflow, as well as modeled simulations for an extruded-based bioprinting setup.

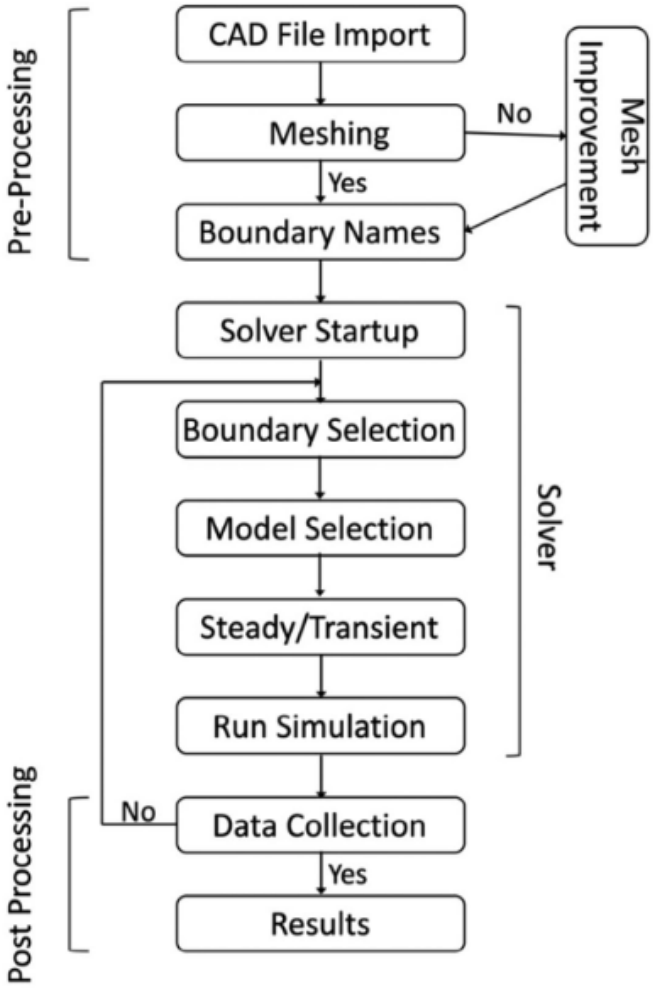



**Figure 3.** The detailed CFD methodology with the pre-processing, solver, and post-processing.[90]

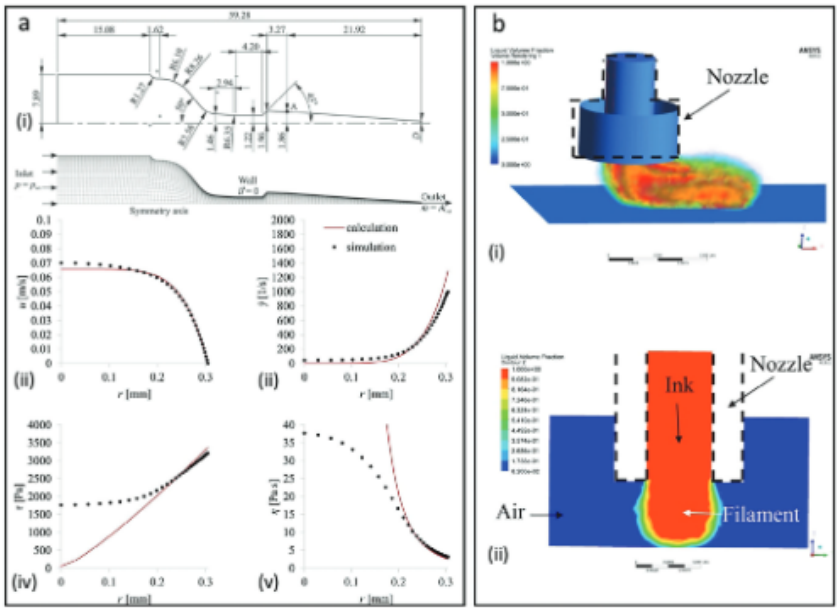



**Figure 4.** CFD for extruding-based bioprinting. a-i) The geometry and the mesh and boundary conditions of a 2D axisymmetric CFD model. The dimensions are in mm. ii–v) For a printing needle with an outlet radius diameter $D = 0.61$ mm and mass flow rate $\dot{m} = 12.37$ mg $s^{-1}$, distribution of selected flow parameters obtained from analytical calculation (red line) and CFD simulation (dotted black line) are graphed. ii) Axial velocity, iii) shear rate, iv) shear stress, and v) dynamic viscosity. Adapted with permission.[79] Copyright 2020, IOP Publishing. b-i) Front view of a simulation of filament deposition and ii) side view of a simulation of filament deposition. Adapted with permission.[95] Copyright 2021, Elsevier.

Next Steps:

The team has begun utilizing ANSYS/Fluent for preliminary CFD simulations. The software is new for all team members but the team has worked to gain familiarity with the platform and hopes to expand on future simulations next semester.

# Valve Research

DOMINIQUE GOODEN (degooden@wisc.edu) - Oct 17, 2025, 4:19 PM CDT

**Title: Valves**

**Date:** 17 October 2025

**Content by: Dominique**

**Present:** N/A

**Goals:** Look up current valves on the market that fit client's specifications

**Content:**

**https://docs.google.com/spreadsheets/d/1_eJf7s0CH7DRXAuCqM-0Q0DFqzXmorLvNQot1fb25ew/edit?gid=0#gid=0**

**I created this sheet which outlines the 3 valves I looked at. I assessed the valves based on specifications, lifecycle, # KSMs we can support, etc. More to follow**

# Degradation, fatigue, and failure of resin dental composite materials.

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 8:14 PM CST

**Title:** Degradation, fatigue, and failure of resin dental composite materials.

**Date:** 8 December 2025

**Content by: Dominique**

**Goals:** Learn about different material composites that we can compare to the materials used for the IRE.

**Content:**

Summary:
The article discusses the factors leading to failure for resin based dental composites. Failure could be due to the material properties of the composites, or it could also be due to or exacerbated by external environmental and mechanical factors that degrade the material.

The dental composites contain a polymerizable resin matrix (Bis-GMA, UDMA, TEGDMA), glass particle fillers (SiO2, Ba, Sr), and coupling agents. These combinations of materials strengthen the composites and add bulk to the composite, which aids in its functionality.

The following mechanical tests below were conducted to gather data on macroscopic and microscopic failure for multiple composites. The paper also focused on the role that the environment (air, water, ethanol, saliva) plays in the composite's material properties and how that might reinforce their strength or contribute to failure.

- Fracture toughness tests in tension or bending
    - Goal: measure resistance to crack initiation and growth
- **Brazilian disk (diametral tensile) tests to induce tensile stresses in disk shaped specimens**
    - **Goal: Evaluate fracture behavior in tension**
- Contact fatigue tests involving repeated cyclic loads
- Multiaxial confined compression
- Flexural strength and fatigue tests using 3-point bending

Results: This section will focus on the **diametral tensile tests** which were most related to our project.

The main results were that fracture toughness in the dry air exposed composites was higher, compared to composites exposed to water and ethanol-water mediums. When the specimens experienced cyclic lloading, the fracture toughness decreased. This increases

the likelihood of early fatigue and cracks under repeated stresses. Finally, composites with an optimized filler distribution had higher toughness. This shows that the uniformity of fillers in a material is a key factor in its toughness.

Conclusions/Next Steps:
This article was relevant to our project because it is an example of testing failure properties in a biocompatible material. Additionally, there were many parallels due to the interaction of our IRE with solid and liquids, similar to how the dental composites would exist in the mouth and interact with various mediums. As the team works to improve the IRE design, it is worth considering the material properties of the IRE and how that might contribute to its overall performance.

Source:

Drummond JL. Degradation, fatigue, and failure of resin dental composite materials. J Dent Res. 2008 Aug;87(8):710-9. doi: 10.1177/154405910808700802. PMID: 18650540; PMCID: PMC2561305.

# Valve-based consecutive bioprinting method for multimaterial tissue-like constructs with controllable interfaces.

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 10:45 PM CST

**Title:** Valve-based consecutive bioprinting method for multimaterial tissue-like constructs with controllable interfaces.

**Date:** 3 December 2025

**Content by: Dominique**

**Goals:** Learn about different bioprinting frameworks

Source:

Wang H, Guo K, Zhang L, Zhu H, Li S, Li S, Gao F, Liu X, Gu Q, Liu L, Zheng X. Valve-based consecutive bioprinting method for multimaterial tissue-like constructs with controllable interfaces. Biofabrication. 2021 Apr 2;13(3). doi: 10.1088/1758-5090/abdb86. PMID: 33440361.

**Content:**

Summary: The paper utilizes a novel valve-based consecutive bioprinting strategy that prints bioinks in series to print high resolution tissue constructs. Rather than changing output nozzles, the VCB switches the inks through a rotation method. This allows materials to be deposited continuously and without interruption.

The bioprinter setup consists of one singular head with various bioink cartriadges that switches between bioinks in a continuous fashion. This system is regulated based on valve opening time and pressures to appropriately control how much volume is deposited and for how long.

This results in material printing, characterized by two types of interfaces:

1. Boundary: one ink stops and next ink starts at a sharp linear border
2. Suture: alternating segments interlock to reinforce junctions

The inks used were modeled as a Maxwell-type viscoelastic material that decouples stored elastic energy in the reservoir from the precise dispensing at the nozzle.

In the paper, the authors printed a muscle tissue construct with vasculature and suture interfaces. They added C2C12 myoblasts and human dermal fibroblasts in different bioink channels and printed them out. Once done, cell viability testing and cell distribution/morphology studies were conducted to validate the cell placement within the regions. Mechanical testing was also conducted on the samples.

Additionally, they also evaluated the bioprinter’s performance metrics such as printing time, switch delay, and print errors.

Results:
The printed specimens from the VCB setup displayed more geometrically accurate suture interfaces between bioinks. These samples also demonstrated higher material strength across the interfaces, compared to the specimens printed from traditional multi-nozzle bioprinters.

Additionally, cells remained in their predefined regions and demonstrated good viability. This demonstrates the compatibility of biological materials with the VCB setup and potentially hints at ways to bioprint more efficiently.

Conclusions/Next Steps:
As the team improves the final IRE design and conducts more testing in the Spring semester, the team can revisit this article to learn more about how to manage fluid flow and print effective vascularized networks.

# Laser-induced forward transfer based laser bioprinting in biomedical applications

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 11:05 PM CST

**Title:** Laser-induced forward transfer based laser bioprinting in biomedical applications

**Date:** November 23, 2025

Source: Chang J, Sun X. Laser-induced forward transfer based laser bioprinting in biomedical applications. Front Bioeng Biotechnol. 2023 Aug 21;11:1255782. doi: 10.3389/fbioe.2023.1255782. PMID: 37671193; PMCID: PMC10475545.

**Content by: Dominique**

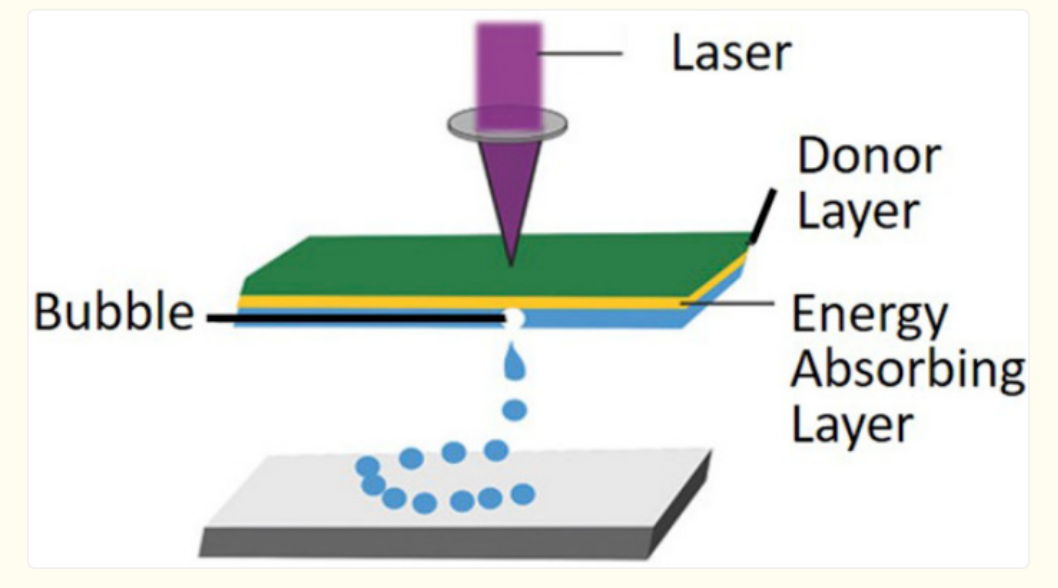
**Goals:** Learn about non extrusion-based bioprinting applications

**Content:**

Summary:

Laser-induced forward transfer (LIFT) bioprinting is a contactless method that uses a pulsed laser to transfer cells and bioinks from a **donor substrate** to a receiving substrate. The **donor substrate** consists of a transparent glass slide coated with two key layers: (1) an **energy-absorbing layer** (typically a thin metal film like Ti or Au, or a biocompatible absorber) directly on top of the glass, and (2) the bioink layer (cells + hydrogel) on top of the absorber.

Beam splitters and lenses focus the laser beam onto the **energy-absorbing layer** at the glass-bioink interface. The laser light is absorbed, and its photon energy is converted into heat. This forms a high-pressure bubble that leads to a precise droplet of bioink forward through a small air gap (~100-500 μm) onto the receiving substrate (often coated with a soft hydrogel for cell cushioning).



LIFT is particularly great for high print accuracy and quality, high throughput, and high cell viability. Moreover, nozzles are not used during LIFT bioprinting, so this minimizes fluid clogging during the process (fluid clogging is a common issue in extrusion-based bioprinting). Because of these advantages, LIFT can be combined with bioprinting modalities to enhance the bioprinting workflow and output quality. LIFT has been successfully used for bioprinting DNA, proteins, endothelial and stem cells. One disadvantage of LIFT is its high cost, which makes it less widely used in research applications.

Next steps: None, given that the lab does not currently use LIFT. This review was mainly for informational purposes.

# 3D-printed triaxial nozzles fabricated by stereolithography to prevent backflow in soft matter biofabrication

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 14, 2025, 11:06 PM CST

**Title:** 3D-printed triaxial nozzles fabricated by stereolithography to prevent backflow in soft matter biofabrication

**Date:** December 13 2025

**Content by: Dominique**

Source: Albalawi HI, Alhattab DM, Konstantinidis AP, et al., 2023, 3D-printed triaxial nozzles fabricated by stereolithography to prevent backflow in soft matter biofabrication. Mater Sci Add Manuf, 2(3): 1786. https://doi.org/10.36922/msam.1786

**Goals:** Understand how backflow concerns were resolved in bioprinting setups

**Content:**

Summary:

Bioprinting is a novel method to produce biocompatible tissue constructs for various applications. However, challenges remain with the nozzle design due to fluid diversion issues during multi-material extrusion. Backflow disrupts the intended material pattern output of the hydrogel and poses mechanical risks to the broader bioprinting setup. Backflow concerns are often mitigated with pressure-driven extrusion, but introducing higher pressures involves risks to the hydrogel print as well as operational safety risks. The authors determine that modifying the nozzle could be a potential solution to prevent backflow.

Rather than changing pre-existing bioprinting workflows, the study team engineered a triaxial nozzle via stereolithography to minimize backflow in the mixing region where multiple bioinks converge. The design maintains a 90-degree valve orientation to promote smooth, unidirectional flow. This geometry-based solution improves extrusion stability and minimizes performance risks.

The nozzle’s performance was evaluated through shape fidelity and print stability. Results demonstrated improved structural integrity and reduced backflow compared to conventional nozzle designs, validating the effectiveness of the proposed geometry in solving the identified biofabrication challenge.

Next steps:

Consider whether CEVIC or IRE can be modified geometrically to minimize backflow wherever appropriate.

# Template entry page

DOMINIQUE GOODEN (degooden@wisc.edu) - Sep 24, 2025, 5:23 PM CDT

**Title:**

**Date:**

**Content by: Dominique**

**Present:** Dominique

**Goals:**

**Content:**

# Clamp Mechanism Tube Holder

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 15, 2025, 8:49 PM CST

Download

**tube_holder_updated_23_oct2025.SLDPRT (103 kB)**

DOMINIQUE GOODEN (degooden@wisc.edu) - Dec 15, 2025, 9:16 PM CST

Content by: Dominique

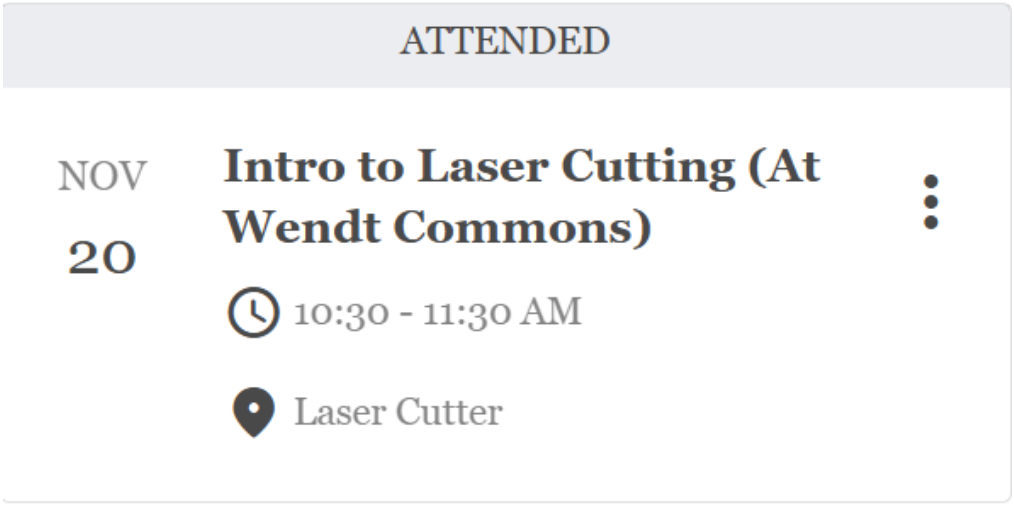
Summary:

The file above depicts a tubing holder to test various shutoff valve mechanisms for the clamp design with current tubing. The tubing sits horizontally flat across the long divide. Then there is a divide in the middle to test the rotational arm/gear clamping the tubing straight down. Towards the end, there is a small box that would hold the gear in place to test horizontal shutoff mechanisms (i.e. a gear rotating flat in a circular fashion).

When conducting preliminary testing, the gear and rotational arm failed to produce enough torque to clamp the tubing for both vertical and horizontal shutoff mechanisms. Afterwards, more research was conducted and now points in a direction of modifying the IRE to assist in fluid shutoff mechanisms without the need for clamping.  That will be elaborated on next semester.

# Laser Training Confirmation

DOMINIQUE GOODEN (degooden@wisc.edu) - Nov 28, 2025, 12:23 PM CST




DOMINIQUE GOODEN (degooden@wisc.edu) - Nov 28, 2025, 12:23 PM CST


UW Madison Design Innovation Lab

215 N Randall Ave., Makerspace, Madison, Wisconsin, 53706

Registration Confirmation

DOMINIQUE ELIANA GOODEN — Date of Birth: Not Supplied

DEGOODEN@WISC.EDU

Program Registration Information

Order #: 0-17856

Invoice #: I-17128

Registration #: R-16898

Total Before Tax: $0.00

Date/Time Registered: 11/11/2025 3:04:36 PM

Program Name: Intro to Laser Cutting (At Wendt Commons)

Program Code:

Program Description: You must be logged in to see the available sessions. Use the "Sign In" link at the top right to sign in with your NetID

Offering Instance: Thu, Nov 20 2025 10:30 AM to 11:30 AM

Offering Notes:

Optional Add On Products

Quantity | Name | Description

Schedule

| Summary | Start Date | Time | Location |
|---|---|---|---|
| | Thu, Nov 20 2025 | Thu, Nov 20 2025 10:30 AM to 11:30 AM | Laser Cutter |

Fri, Nov 28 2025 1:21P — Page 1 of 1

Download

**RegistrationConfirmation_DOMINIQUE_ELIANA_GOODEN.pdf (32.1 kB)**

# 12 September Meeting

DOMINIQUE GOODEN (degooden@wisc.edu) - Sep 12, 2025, 1:32 PM CDT

Name: Dominique

Present: All + Advisor

# Circuit Testing Protocols

DOMINIQUE GOODEN (degooden@wisc.edu) - Nov 19, 2025, 6:58 PM CST

**Title: Circuitry Testing Protocols**

**Date:** 18 Nov 2025

**Content by: Dominique**

**Present:** n/a

**Goals:** create a circuit testing protocol for 19 November 2025 testing

**Content:**

Possible Parameters to check (fill in during testing):

**Test I. Measuring Voltage, Current, Resistance:**

Purpose: Gain understanding of electric profile of circuit

a. Black lead --> COM port in multimeter

b. Red lead ---> V port in multimeter (Ohms port for Resistance; A port for Current)

c. Set multimeter to DC or AC depending on circuit type

d. Black wire --> GND in arduino

e. Red wire ---> + terminal

f. Connect and turn power on. Read Measurement

g. Turn power off

h. Record outputs, as well as voltage drops across circuit components

**Expected Parameters:**

Voltage:

Resistance:

Current:

**Measured Parameters (If significantly off, calculate degrees off):**

Voltage:

Resistance:

Current:

**Test II. Measuring Continuity:**

Perform a digital multimeter continuity test to verify the circuit is complete.

Steps:

i. Disconnect power source

ii. Rotate dial on DMM to continuity setting

iii. Insert Black lead ---> COM port and Red Lead -----> V/Ohm jack

iv. Place probes near the parts of the circuit you want to measure continuity in

v. Listen out for a beep

Validation Metric 1: Is circuitry appropriately set up/connected?

Validation Metric 2: Do we hear a beep? Is it continuous or absent?

-Steady beep means circuit is complete/continuous (R = 0 ohms)

- No beep means circuit is not complete and resistance would likely be high

**Test III. Electrical Signal Validation for Servo Rotation**

Purpose: Does the circuit produce enough power to ultimately enact a 60degrees torque change?

Steps:

1. Gather an oscilloscope (perhaps in ECB or ME or Chamberlin) and connect to signal wire of servo motor connection.

2. Ground the oscilloscope probe to the circuit ground.

3. Observe wave output

Validation metric 1: Do we see repetitive square waves?

Validation metric 2: Does it demonstrate the frequency measured in test 1?

Validation metric 3: Does the oscilloscope measure the expected pulse width for the angle input in code? Important because pulse width influences the angular position of the servo arm!

**Test IV: Mechanical Torque Measurement**

Purpose: Ensure the servo motor is functional and can rotate the IRE by 60degrees for each cycle

Steps:

1. Operate code as normal.

2. Allow servo motor arm to rotate and measure displacement with a protractor.

3. Repeat for as many cycles as necessary.

Validation metric 1: Does the servo motor turn with the expected torque? What is that torque? How far off are we?

**Action Items:**

-Could explore measuring Inductance or Capacitance, although more advanced tools are needed to conduct those measurements.

-Check if thermistor was used in circuit. Do we also have an oscilloscope?

- Need to get the expected pulse width for the micro servo motor

**References:** Channel Pulse | REV Crossover | REV Robotics Documentation

# Background research sheet printing

MAHATHI KARTHIKEYAN - Sep 16, 2025, 10:26 AM CDT

**Title: Sheet-Based Extrusion Bioprinting**

**Date:** 9/16

**Content by:** Mahathi

**Present:**

**Goals:** Learn more information on bioprinting and the existing device at hand. Take some notes on what can be improved about the device and discuss with group members.

link: https://pmc.ncbi.nlm.nih.gov/articles/PMC10938191/

Citation:

[1] "Explained: Generative AI's environmental impact," MIT News | Massachusetts Institute of Technology. Accessed: Feb. 21, 2025. [Online]. Available: https://news.mit.edu/2025/explained-generative-ai-environmental-impact-0117

**Content:**

- **To supplement donor tissue that is naturally derived, bioprinting became a method that was popularly used.**

**- This method is also customizable and can be used instead of tissue grafts that are already in place.**

**- However, an important issue that came up is how to improve the vascularization of the tissue to get proper nutrients to sustain the tissue.**

- There also has been progress in bioprinting for microvascular tissue(what we are focusing on) and more complex levels of tissue

- Multi nozel approaches are taking place but switching between them is not automatic however it does prevent cross contamination.

**Conclusions/action items:**

- Discuss how we can solve the multi-nozel problem issue with the valve shutoff device.

- Meet with grad student to learn more about existing device.

# Chaotic Bioprinting

MAHATHI KARTHIKEYAN - Oct 23, 2025, 10:44 PM CDT

**Title: Chaotic Bioprinting for Drug Deliveries**

**Date:** 10/21

**Content by:** Mahathi Karthikeyan: Author: Mario Alvarez

**Present:** NA

**Goals:** Get a background on chaotic printing which is the method for printing hydrogels

Citation:

[1] M. M. Alvarez, A. Cantoral-Sánchez, and G. Trujillo-de Santiago, “Chaotic (bio)printing in the context of drug delivery systems,” *Advanced Drug Delivery Reviews*, vol. 216, p. 115475, Jan. 2025, doi: 10.1016/j.addr.2024.115475.

**Content:**

- chaotic printing is a method to fabricate micromaterials that have various or chaotic flows allowing for high surface area and striations

- This method was created with the process to improve efficiency with mixing which is why it is useful in the context of this process with KSMs, kenics static mixers

- This method can also increase resolution of the vasculature which is its biggest advantage

- Lastly chaotic printing is used to print a variety of materials cells and materials making it versatile

**Conclusions/action items:**

**- Use this application to learn more about the background how this process can be automated**

**- Talk about potential ideas with group**

# Kenics Static Mixers-detailed research

MAHATHI KARTHIKEYAN - Nov 09, 2025, 7:05 PM CST

**Title: " Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications"**

**Date:** 11/9/25

**Content by:** NA

**Present:** Mahathi

**Goals:** Learn more about kenics static mixers and how this is used for bioprinting

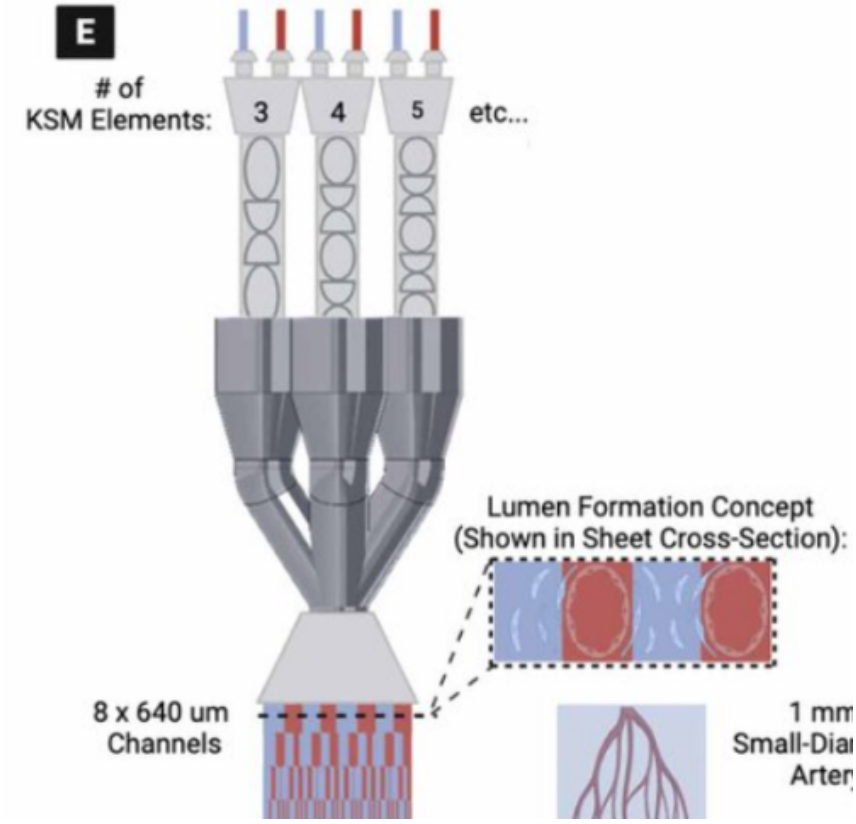
**Content:**

**- Kenics static mixers uses multiple helical blades arranged in a sequential manner**

**-Kenics static mixes can also divide fluid flow and rotates them in the opposite direction**

**- This process also creates alternate striations and flows of the bio ink that is printed for hydrogels**

**-** The continuous flow and diversion creates the chaotic printing mechanism seen by the CEVIC




Citation:

[1] "(A) The kenics static mixer (KSM) mechanism employed in chaotic...," ResearchGate. Accessed: Nov. 09, 2025. [Online]. Available: https://www.researchgate.net/figure/A-The-kenics-static-mixer-KSM-mechanism-employed-in-chaotic-printing-utilizing_fig1_378773129

**Conclusions/action items:**

- Use this application to plan how to use the motor to accurately move the CEVIC device to print hydrogels

- Do background research on competing designs.

# Specifications and Standards for Bio Ink

MAHATHI KARTHIKEYAN - Nov 28, 2025, 7:58 PM CST

**Title:** Standard Guide for Bioinks Used in Bioprinting

**Date:** 11/28

**Content by:** NA

**Present:** NA

**Goals:** Learn about the standards and requirements when using bio ink since that is used for our kenics static mixers

**Content:**

- Printing Considerations:

Cytotoxicity: Bioinks should not be toxic to the cells they are intended to encapsulate

Cell Viability: Cells have to proliferate and remain viable and differentiate appropriate and promote cell survival.

Biocompatibility : No adverse Response should be to the subject when the hydrogel is in contact with the body. Materials have to be biocompatible

Source:

[1] J. Kim, “Characterization of Biocompatibility of Functional Bioinks for 3D Bioprinting,” *Bioengineering (Basel)*, vol. 10, no. 4, p. 457, Apr. 2023, doi: 10.3390/bioengineering10040457.

**Conclusions/action items:**

- Use these requirements for testing cytotoxicity and durability of the cells we choose to grow

- Use the requirements when writing test protocols to have clear standards.

# conventional bioprinting

MAHATHI KARTHIKEYAN - Dec 14, 2025, 11:06 AM CST

**Title: "** Bioprinting: A promising approach for tissue regeneration"

**Date:** 12/14/25

**Content by:** Mahathi Karthikeyan

**Present:** NA

**Goals:** Learn about the use of conventional bioprinting device

**Content:**

**- Bioprinting is emerging in tissue engineering especially of tissue regeneration**

**- There are different techniques for bioprinting**

**- Major types of bioprinting are inkjet bioprinting, microextrusion, and laser- assisted bioprinting methods**

**- This technology has been showing promise in regenerative medicine and can be used with specific bio-ink for each tissue type.**

**Conclusions/action items:**

- This is the baseline for sheet based bioprinting

- This has to be used with the CEVIC device and KSMs for printing the hydrogels with the right resolution so this is a more advanced use of bioprinting.

- Use this for background for chaotic bioprinting.

Citation:

[1] F. Stapenhorst, M. Garrido dos Santos, J. P. Prestes, B. J. Alcantara, M. Felisberto Borges, and P. Pranke, “Bioprinting: A promising approach for tissue regeneration,” *Bioprinting*, vol. 22, p. e00130, June 2021, doi: 10.1016/j.bprint.2021.e00130.

# Microvalve device

MAHATHI KARTHIKEYAN - Dec 02, 2025, 10:10 AM CST

**Title: "**A Novel On-Chip Liquid-Metal-Enabled Microvalve"  12/2/25

**Date:** Aug 30,2021

**Content by:** NA

**Present:** NA

**Goals:** Learn more about competing devices to kenics static mixers and chaotic bioprinting

**Content:**

- This device is overall a liquid metal-valve used to print hydrogels

-Injectable metals were recently used for microfluidics

- Liquid metals were useful because it could preform a fast thermal response

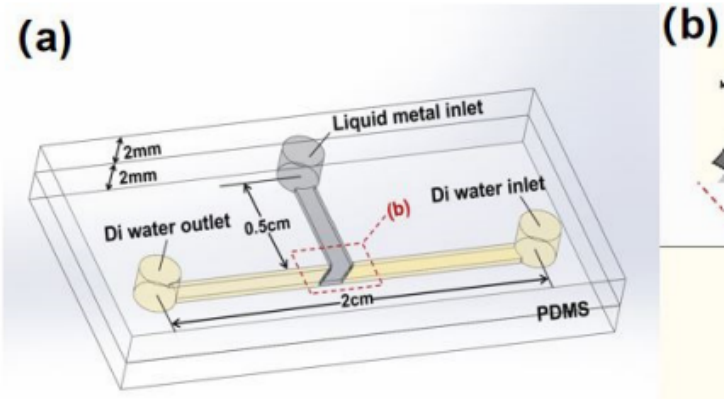
- This device was transitioned to room temperature so it could function as microvalve that is consists of soft metal that does not leak.

- The valve can also open and close properly.

-However lifespan of the microvalve due to metallic effects of metal oxide is a limiting factor.

Citation:

[1] J. Gong, Q. Wang, B. Liu, H. Zhang, and L. Gui, “A Novel On-Chip Liquid-Metal-Enabled Microvalve,” *Micromachines (Basel)*, vol. 12, no. 9, p. 1051, Aug. 2021, doi: 10.3390/mi12091051.




**Conclusions/action items:**

- Learn more about other competing designs and how our bioprinting mechanism has advantages over it.

-This particular design has its advantages but it definitely does not have durability for long term.

# 3D nanoprinting of PDMS microvessels

MAHATHI KARTHIKEYAN - Dec 14, 2025, 10:52 AM CST

**Title: "** 3D nanoprinting of PDMS microvessels with tailored tortuosity and microporosity *via* direct laser writing "

**Date:** 12/14/25

**Content by:** NA

**Present:** NA

**Goals:** Learn more about the competing devices for our shutoff valve switching mechanism.

**Content:**

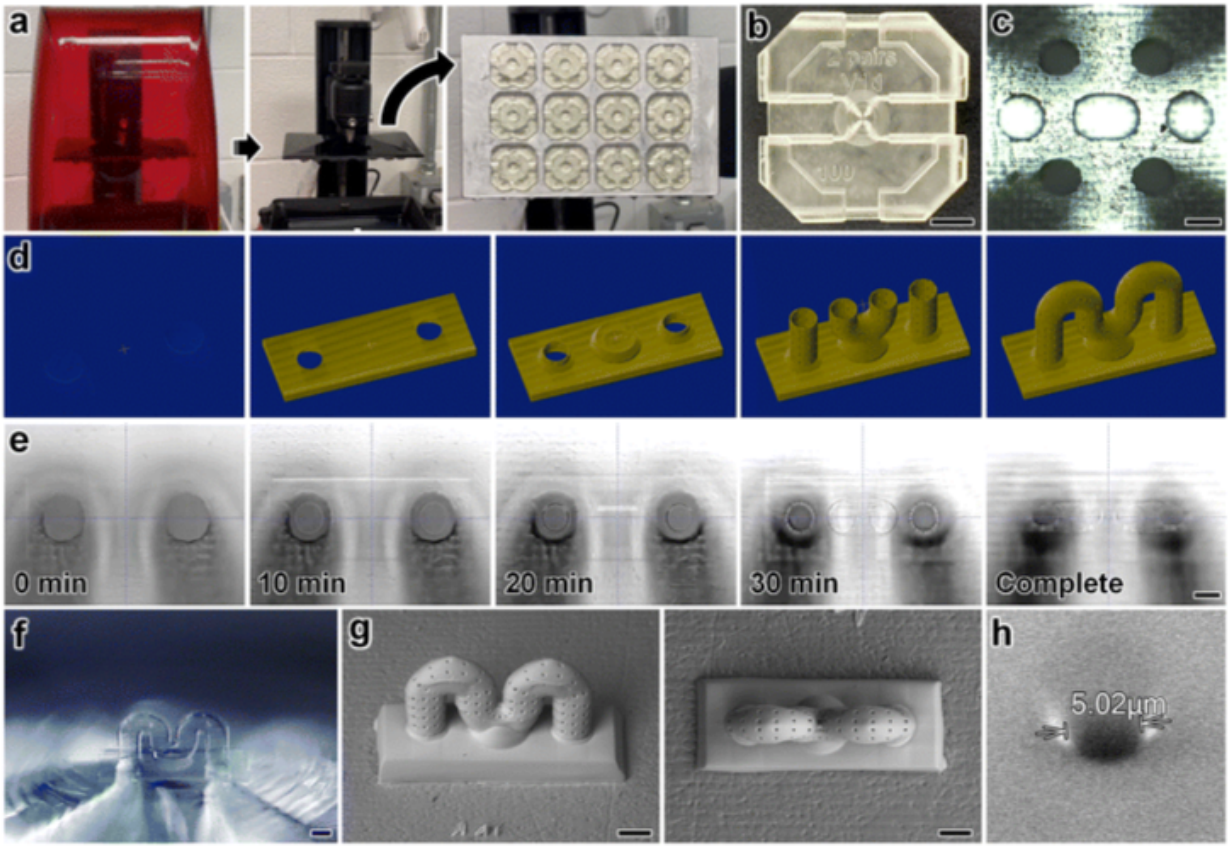
-Microvessels represent a key part of building blocks of all organ systems in the body

- However modeling these vessels in-vivo is still is a challenge

- A method that is explored in this paper is protocols in which microfluidic structures are printed directly outside of a fully enclosed microfluidic channels instead of inside

- This along with the ability of using PDMS for mircovessels is explored.

- The results show promise for seamless fabrication of microfluidic devices that can mimic vasculature.




**Conclusions/action items:**

- This method is a way for in-vivo modeling of vasculature and is used for complex modeling for DLW-3D printers

- This is not much applicable for our device but this is a good device to get research on for backrgound.

- Talk about with group and see if parts can be used next semester.

Citation:

[1] X. Xu *et al.*, “3D nanoprinting of PDMS microvessels with tailored tortuosity and microporosity via direct laser writing,” *Lab Chip*, vol. 25, no. 8, pp. 1947–1958, Apr. 2025, doi: 10.1039/D4LC01051E.

# Pinch Valves

MAHATHI KARTHIKEYAN - Nov 02, 2025, 10:16 PM CST

**Title: Pinch Valves**

**Date:** 11/2/2025

**Content by:** Pinch Valves for clamp design

**Present:** NA

**Goals:** For our current design that includes the clamping component to be automated and to stop flow. This pinch valve could be a potential idea and has the potential to work with Arduino or Labview

**Content:**

- The pinch valve is a control mechanism using a pinching affecting fluid flow of a object

- For our purposes we would control multiple pinch valves to stop or start fluid flow coming out of the kenics static mixer

- This mechanism works by energizing the solenoid which retracts or attracts the mechanism

- This can be bought as a normally open or closed valve or closed/open configuration

Citation:

[1 "Pinch Valve | 2, 3 Way, Normally Closed/Open, Solenoid-operated | PreciGenomeLLC, USA," PrecigenomeLLC. Accessed: Nov. 02, 2025. ] [Online]. Available: https://www.precigenome.com/microfluidic-fluidic/solenoid-operated-pinch-valve

**Conclusions/action items:**

**- This valve unfortunately is quite expensive for buying 6-7 valves.**

**- The group will discuss alternatives such as servo motors.**

# Servo Motor documentation

MAHATHI KARTHIKEYAN - Nov 09, 2025, 6:29 PM CST

**Title: Servo motor documentation**

**Date:** 11/9/25

**Content by:** NA

**Present:** Mahathi

**Goals:** Learn basics about servo motor because it can be used for the IRA design.

**Content:**

**- Servo motors can be integrated with Arduino with three wires, power, ground, and signal**

**-Servo motors can rotate from 0-180 degrees and the specific angle can be chosen**

- The power wire on the arduino is red, signal pin is yellow orange or white and should be connected to a digital pin on the arduino

Sample code:

```
#include <Servo.h>

Servo myServo;  // create servo object to control a servo
int servoPin = 9; // digital pin (PWM) to connect the servo

void setup() {
  myServo.attach(servoPin);  // attaches the servo on pin 9 to the servo object
}

void loop() {
  // Move the servo to 0 degrees
  myServo.write(0);
  delay(1000); // wait for a second

  // Move the servo to 90 degrees
  myServo.write(90);
  delay(1000); // wait for a second

  // Move the servo to 180 degrees
  myServo.write(180);
  delay(1000); // wait for a second
}
```

Attach is for putting the servo to a specific pin

Citation:

[1 “Servo | Arduino Documentation.” Accessed: Nov. 09, 2025. [Online]. Available: https://docs.arduino.cc/libraries/servo/
]

**Conclusions/action items:**

- Explore using servo motors for the IRE design to rotate the Kenis Static Mixers.

- Talk to team about purchasing multiple motors.

# Updated Code for Circuit Testing

MAHATHI KARTHIKEYAN - Nov 28, 2025, 9:15 AM CST

**Title: Code for testing the functionality of the circuit.**

**Date:** 11/28

**Content by:** NA

**Present:** NA

**Goals:** - To test the servo motor to show functionality with the IRE design. Two parameters that are tested are the appropriate angle measurements and time it takes to switch between kenics static mixers.

**Content:**

Angle measurement code for 60 degrees:

```
#include <Servo.h>


Servo myservo;  // create servo object to control a servo

// twelve servo objects can be created on most boards


int pos = 0;    // variable to store the servo position


void setup() {

  myservo.attach(5);  // attaches the servo on pin 9 to the servo object

}


void loop() {

 myservo.write(0);

 delay(1000);

 myservo.write(60);

 delay(1000);

}
```

Angle measurement for 90 degrees:

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo
// twelve servo objects can be created on most boards

int pos = 0;    // variable to store the servo position

void setup() {
  myservo.attach(5);  // attaches the servo on pin 9 to the servo object
}

void loop() {
 myservo.write(0);
 delay(1000);
 myservo.write(90);//Change to 180 for testing 180 degrees
 delay(1000);
}
```

I also tested the time it takes to move from one Kenics Static Mixer to the Other.

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo

// twelve servo objects can be created on most boards

int pos = 0;    // variable to store the servo position

int mills= 0;

void setup() {

  myservo.attach(5);  // attaches the servo on pin 9 to the servo object

}

void loop() {

 myservo.write(0);

 delay(1000);

 myservo.write(60);

 delay(1000);

 mills= millis()

}
```

**Conclusions/action items:**

- Analyze results and use it in terms of the IRE design and functionality testing for motor.

# Circuit testing

MAHATHI KARTHIKEYAN - Dec 01, 2025, 10:51 PM CST

**Title: Testing for circuit functionality**

**Date:** 11/25

**Content by:** NA

**Present:** NA

**Goals:** Test the circuit for functionality by getting angle values and time it takes to switch between kenics static mixers.

**Content:**

60 degrees:

| Angle Set by Servo | 60 | 90 | 180 |
|---|---|---|---|
| Actual Angle(deg) | 62,61,62 | 91,90,92 | 180,182,182 |

Time testing in seconds:

Trial 1:

0.21

0,22

0.21

Trial2:

0.21

0.23

0.23

Trial3:

0.22

0.22

0.22

**Conclusions/action items:**

**- The values show that the servo motor angles closely algin with the actual angles and the motor works well for the IRE design. It also takes a relatively short time switching between KSM's. Report findings to group and discuss how this works overall with the IRE design.**

# Circuit Diagram

MAHATHI KARTHIKEYAN - Dec 01, 2025, 11:10 PM CST

**Title: Diagram of arduino final circuit**

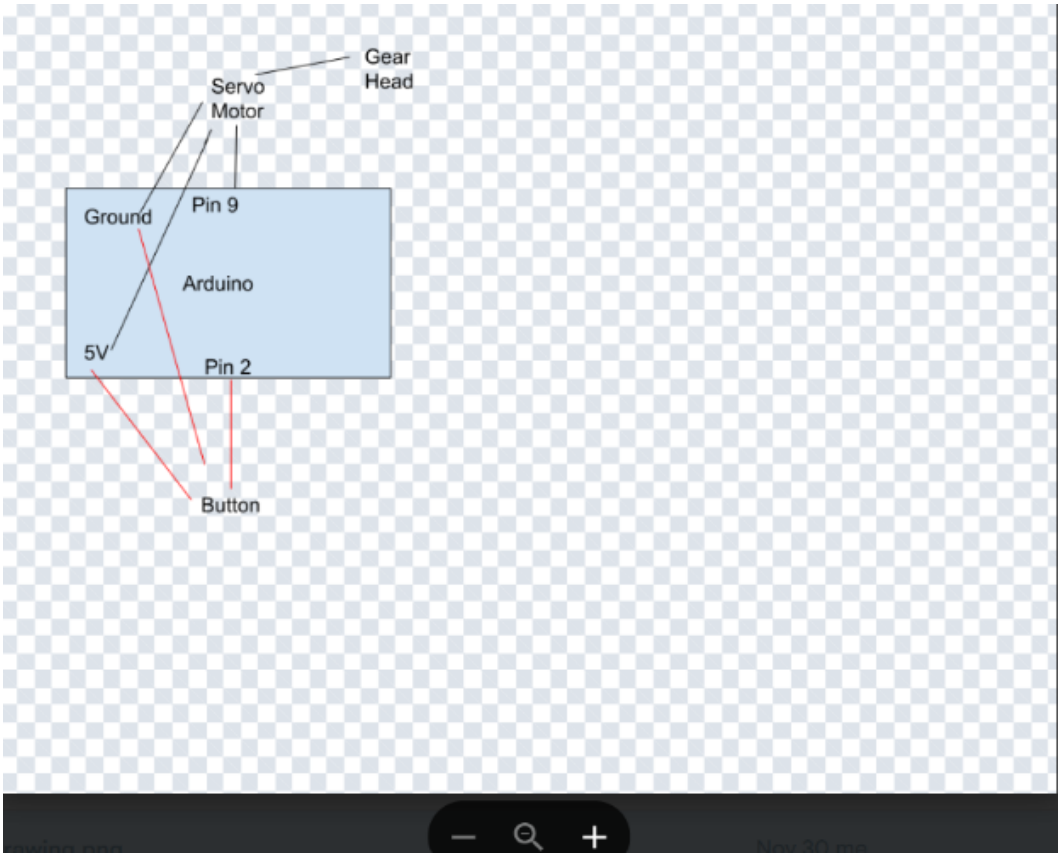
**Date:** 12/1

**Content by:** NA

**Present:** NA

**Goals:** Have a diagram of the working circuit to reference

**Content:**




**Conclusions/action items:**

1. Use the diagram for the final circuit during the poster session. Reference this diagram to show the audience. Build upon this circuit later using relay siwtch.

# 2025/09/25 - Comparison Table Rotary Valves

ANA CLARA TOSCANO - Sep 24, 2025, 6:54 PM CDT

**Title: Comparison Table Rotary Valves**

**Date:** 09/25

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Look into rotary valves & what is available - compile some and send to Josh

**Content:**

| Vendor / Model | Ports & Configs | Control / Integration | Pros | Cons / Limitations | Flexibility |
|---|---|---|---|---|---|
| **VICI / Valco (Cheminert + actuators)** | 4–12+ ports (Cheminert C52, C62; Valco actuators on many valves) | USB, RS-232; vendor DLLs; widely used with LabVIEW (VISA serial) | • Industry standard in chromatography & automation• Mature docs + community support• Wide chemical compatibility (PTFE, stainless)• Good longevity ($10^6$+ cycles) | • Pricing on higher side• Some models require separate actuator + controller purchase• OEM-style (may need some integration effort) | High — many port options, interchangeable valve heads, multiple actuator/controller options |
| **Hamilton MVP (Modular Valve Positioner)** | 6, 8, 10, 12 ports (swappable heads) | RS-232 (ASCII protocol); easy with LabVIEW serial | • Modular design: swap valve cartridges quickly• Well supported in lab automation• Good vendor documentation | • Needs external positioner (controller + head = two parts)• Slower switching vs. microfluidic valves• Bulkier than Elveflow | Medium-High — flexible port counts but limited to MVP ecosystem |
| **Elveflow Rotary Valve Controller** | Up to 12 ports | USB / serial API, SDK for automation | • Compact footprint• Designed for microfluidics (low dead volume)• Sequencing modes built in• Easy scripting | • Flow rates & pressures limited (not for high-pressure chromatography)• Smaller vendor ecosystem• More expensive per port than Valco | Medium — very good for small-scale automated experiments, less so for heavy fluidics |
| **Aurora / AuroraProSci Selector Valves** | 6–16 ports | Stepper motor driven; controlled by serial/USB motion controller | • Cost-effective• Large port count (up to 16)• Customizable head materials | • Requires separate stepper driver/controller• Integration complexity higher• Limited vendor software ecosystem | High — broad port counts; can adapt controller choice; flexible but more DIY |
| **PreciGenome SwitchEZ Rotary Selector** | 6, 8, 10, 12 ports | Stepper/servo motor; USB/serial | • Small footprint• Leak-free design• Affordable OEM option | • Requires tuning of controller• Fewer out-of-the-box software drivers• Smaller vendor support base | Medium — solid for OEM prototyping; less off-the-shelf friendly |
| **IDEX / AMF OEM Valves** | Customizable (6–12+ ports) | Designed for OEM integration; controller varies | • Robust valves, high-pressure options• Many material choices (PEEK, PTFE, stainless) | • OEM focus, not always off-the-shelf• Need to pair with own motor/controller• Limited direct LabVIEW resources | Very High (custom OEM options), but requires engineering effort |

**Conclusions/action items: Share some notes with Josh next meeting.**

# 2025/11/14 - Research on Viscosity Value for Simulation

ANA CLARA TOSCANO - Nov 14, 2025, 12:40 PM CST

**Title:** Fluid Behavior Assumptions in Continuous Chaotic Printing (Chávez-Madero et al. 2020)

**Date:** 11/14

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Citation:** Chávez-Madero, C., Díaz de León-Derby, M., Samandari, M., Ceballos-González, C. F., Bolívar-Monsalve, E. J., Mendoza-Buenrostro, C., Holmberg, S., Garza-Flores, N. A., Almajhadi, M. A., González-Gamboa, I., Yee-de León, J. F., Martínez-Chapa, S. O., Rodríguez, C. A., Wickramasinghe, H. K., Madou, M., Dean, D., Khademhosseini, A., Zhang, Y. S., Alvarez, M. M., & Trujillo-de Santiago, G. (2020). Using chaotic advection for facile high-throughput fabrication of ordered multilayer micro- and nanostructures: continuous chaotic printing. *Biofabrication*, *12*(3), 035023. https://doi.org/10.1088/1758-5090/ab84cc

**Goals:** Determine important parameters like viscosity for simulation protocol

**Content:**

The concept of continuous chaotic printing relies on the use of a simple laminar chaotic flow induced by a static mixer. Chaotic flows are employed to achieve mixing in the **laminar regime**, which is defined by conditions of **low speed and high viscosity** where turbulence cannot be used to achieve homogeneity.

Key assumptions and conditions regarding fluid behavior:

1. **Laminar Flow:** The entire process operates under a laminar flow regime.
2. **Newtonian Behavior:** The printing process is stable and robust across a wide range of operational settings, provided that the **flow regime is laminar and the fluid behaves in a Newtonian manner**.
3. **Predictability (Deterministic System):** Chaotic flows are deterministic systems, meaning the resultant internal structure is fully **predictable**. This predictability is verified through computational simulations.
4. **Computational Fluid Dynamics (CFD) Parameters:** Simulation results were obtained by solving the Navier-Stokes equations of fluid motion using CFD. For these computational simulations, specific fluid behavior parameters were defined:
    - A fluid **viscosity value of 1 Pa·s**.
    - A **density of 1000 kg $\text{m}^{-3}$**.
    - Laminar flow equations and a stationary solver were used to determine the velocity field.

The flow within the Kenics Static Mixer (KSM) printhead must maintain this **laminar flow regime** because the KSM generates chaos by repeatedly splitting and reorienting materials as they pass through each helical element. This is successful across a wide range of tested flow conditions (e.g., stable fibers were obtained in a window of flow rates from 0.003 to 5.0 ml $\text{min}^{-1}$) as long as the laminar and Newtonian assumptions hold.

**Conclusions/action items:**

The resemblance between experimental microstructures and those generated by **rigorous modeling using CFD simulations** confirms that the fundamentals of chaotic printing are solid and predictable. The use of chaotic flows for printing ensures that resolution is increased without increasing the shear rate forces, which is essential for maintaining high post-printing cell viability in bioprinting applications. The predictability rooted in the fundamental physics of chaotic advection means that the reproducible, non-uniform distribution of length scales (striation thickness distribution, STD) can be calculated by simulations.

To understand the deterministic nature of chaotic flows in this context, imagine a perfectly controlled taffy puller: **While the final shape of the pulled taffy (the lamellae) might look complex and random to the naked eye, every stretch and fold is governed by precise, known forces, making the final structure completely predictable and repeatable, even down to the smallest filament thickness.**

# 2015/11/14- Chaotic Bioprinting Assumptions for Simulation

ANA CLARA TOSCANO - Nov 14, 2025, 12:47 PM CST

**Title:** Fluid Behavior and Viscosity Assumptions in Continuous Chaotic Bioprinting of Skeletal Muscle-like Constructs (Bolívar-Monsalve et al., 2021)

**Date: 11/14**

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine assumptions of Chaotic Bioprinting Assumptions for Simulation

**Citation:** Bolívar-Monsalve, E. J., Ceballos-González, C. F., Borrayo-Montaño, K. I., Quevedo-Moreno, D. A., Yee-de León, J. F., Khademhosseini, A., Weiss, P. S., Alvarez, M. M., & Trujillo-de Santiago, G. (2021). Continuous chaotic bioprinting of skeletal muscle-like constructs. *Bioprinting*, *21*, e00125. https://doi.org/10.1016/j.bprint.2020.e00125

**Content:**

The efficacy of Continuous Chaotic Bioprinting relies entirely on specific assumptions regarding the fluid behavior, particularly the rheological properties of the hydrogel bioinks and the flow regime achieved during coextrusion.

Key viscosity and fluid behavior assumptions/conditions:

1. **Laminar Flow Regime:** The creation of the layered structures depends on mixing the two hydrogel inks in a **laminar flow regime**. Maintaining laminar flow throughout the process is critical, as this condition inherently **minimizes the shear stress on the cells**, enabling high post-printing viability (initially $>85%$).
2. **Newtonian-like Behavior:** For effective chaotic advection to occur, the hydrogel inks chosen must exhibit **Newtonian-like behaviors** at the operational working conditions. This ensures the chaotic mixing is predictable and controllable.
3. **Rheological Compatibility:** An appropriate combination of inks is crucial, necessitating that the inks be **compatible in terms of rheology, density, polarity, and interfacial tension** for successful generation of structures.
4. **Temperature Requirements:** The coextrusion process must be performed at a temperature range that is **distant (higher) from the sol-gel transition temperature** ($T_{sg}$) of the inks to prevent nozzle clogging.
5. **Predictability and Determinism:** Chaotic flows are deterministic systems. The structure obtained is fully **predictable** and is amenable to **mathematical modeling**.
6. **Computational Fluid Dynamics (CFD) Parameters:** Computational simulations were implemented using a multiphase model to mimic the coextrusion of fluids through the KSM printhead. The CFD simulations relied on specific fluid property assumptions:
    - A **viscosity ratio of 1:1** was considered, with a set viscosity value of **0.2 Pa$\cdot$s**.
    - A **density of 1000 kg $\text{m}^{-3}$** was considered.
    - The Navier-Stokes equations for a **laminar flow** were solved in a transient state.
7. **Velocity Field Stability:** The predictability extends to the flow dynamics. CFD simulations demonstrated that the distribution of velocity profiles (and thus shear stress) is **quite similar** after each KSM element, and the velocity field is **not altered when the number of KSM elements is increased**. This is a critical finding because it allows resolution (layer thickness) to be enhanced (e.g., from $\sim 130\ \mu\text{m}$ to $\sim 22\ \mu\text{m}$) simply by increasing the number of KSM elements without increasing the detrimental mechanical shear stress induced by the flow.

**Conclusions/action items:**

The rheological constraints (laminar flow, Newtonian-like behavior) and the predictability confirmed by CFD modeling validate CCB as a simple and robust method for creating complex, high-resolution internal microstructures in tissue engineering. Crucially, the system's reliance on laminar chaotic flow allows for the resolution to be **enhanced without increasing shear rate forces**, which is essential for maintaining **high post-printing cell viability** (observed to be $>86%$). The predictability allows the internal architecture (the striations/layers) to be precisely controlled, which, in this study, promoted effective **cell alignment ($\sim 60%$)** within the biofabricated muscle constructs.

The relationship between predictability, low shear, and enhanced resolution in CCB is akin to a master potter working with a specifically formulated, pliable clay: **Because the clay's viscosity is perfectly suited to laminar flow (Newtonian-like), the potter can continuously stretch and fold it (using the KSM) to create exponentially thinner, organized internal layers without causing the material to tear or become turbulent, thus producing intricate, micro-thin structures that are highly repeatable.**

# 2025/11/20 - Treatment Of A Microvascular Reconstructed Mandible Using An Implant-Supported Fixed Partial Denture: Case Report

ANA CLARA TOSCANO - Dec 10, 2025, 5:26 PM CST

**Title:** Treatment Of A Microvascular Reconstructed Mandible Using An Implant-Supported Fixed Partial Denture: Case Report

**Date:** 2025/11/20

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Case study for impact and applications

Citation:

Knabe, C., Stiller, M., Kampschulte, M., Janka Wilbig, Peleska, B., Jens Günster, Gildenhaar, R., Berger, G., Rack, A., Ulf Linow, Heiland, M., Carsten Rendenbach, Steffen Koerdt, Steffen, C., Houshmand, A., Xiang-Tischhauser, L., & Doaa Adel-Khattab. (2023). A tissue engineered 3D printed calcium alkali phosphate bioceramic bone graft enables vascularization and regeneration of critical-size discontinuity bony defects in vivo. *Frontiers in Bioengineering and Biotechnology*, *11*. https://doi.org/10.3389/fbioe.2023.1221314

**Content:**

- Problem: A mandibular discontinuity defect (a missing segment of the lower jawbone) caused by a gunshot wound. This leads to severe cosmetic, chewing, speaking, and swallowing problems. A conventional removable denture on such a defect is unstable and inadequate.
- Solution: A two-stage, team-based approach:
    1. Surgical Reconstruction: Oral and plastic surgeons performed a one-stage hemimandibulectomy (removal of the damaged bone) with immediate reconstruction using a vascularized free fibula graft from the patient's leg. This restored jaw continuity using living, healthy bone.
    2. Prosthetic Rehabilitation: A prosthodontist later placed osseointegrated dental implants into the healed grafted bone and fabricated a fixed, implant-supported bridge to replace the missing teeth.

## Key Clinical Details & Outcome

- Procedure: Three implants were initially placed; one failed to integrate, leaving two successful implants.
- Challenge: The two remaining implants were in a relatively straight line, which is not ideal for supporting a fixed bridge without a cantilever (an extension). A cantilevered fixed bridge was therefore fabricated.
- Result: The implant-supported bridge was successfully cemented. It restored function and aesthetics, providing a stable prosthetic solution far superior to a removable denture. The patient's main remaining complaints were related to the original soft tissue damage (tongue mobility issues), not the bone graft or implants.

**Conclusions/action items: T**his case is a classic example of modern maxillofacial rehabilitation, combining advanced microvascular surgery for biological reconstruction with implant dentistry for functional restoration, offering patients with severe jaw defects a chance at a near-normal life.

# 2025/11/25 - MICROVASCULAR BONE RECONSTRUCTION IN COMPLICATED FRACTURES AND BONE DEFECTS

**Title:** MICROVASCULAR BONE RECONSTRUCTION IN COMPLICATED FRACTURES AND BONE DEFECTS

**Date:** 2025/11/25

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Understand the application of bone reconstruction

Citation: Tukiainen, E. (2004). S2024 MICROVASCULAR BONE RECONSTRUCTION IN COMPLICATED FRACTURES AND BONE DEFECTS. Orthopaedic Proceedings, 86-B(SUPP_III), 209

**Content:**

Comparison of Bone Defect Reconstruction Methods

**Conclusions/action items:** Microvascular bone grafts are not a first-line treatment for all defects. They are a high-resource, high-skill option rese

# 2025/12/10 - Microvascular Head and Neck Reconstruction

ANA CLARA TOSCANO - Dec 10, 2025, 5:55 PM CST

**Title:** Microvascular Head and Neck Reconstruction

**Date:** 2025/12/10

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine impact

citation:

Health, U. (2024, April 12). *Microvascular Head and Neck Reconstruction*. Ucsfhealth.org; UCSF Health. https://www.ucsfhealth.org/treatments/microvascular-head-and-neck-reconstruction

**Content:**

1. Indications (When It's Used):
    - Primary: Reconstruction after removal of head and neck cancers (oral cavity, tongue, jaw, throat, etc.).
    - Secondary: Treating complications from cancer treatment like osteoradionecrosis (jawbone death from radiation), non-healing wounds, and functional deficits (e.g., swallowing problems, nasal obstruction).
2. The Procedure (Free Tissue Transfer):
    - Team 1: Removes the tumor.
    - Team 2: Simultaneously harvests the free flap (the tissue graft) and, after tumor removal, transplants it. A microscope is used to suture the flap's tiny blood vessels to vessels in the neck to keep it alive.
    - Common donor sites and their uses:
        - Fibula (leg bone): For jaw (mandible) reconstruction.
        - Anterolateral Thigh (skin/fat): For covering large soft tissue defects, tongue or throat lining.
        - Radial Forearm (skin): A traditional workhorse for lining the mouth or throat.
        - Latissimus Dorsi (back muscle): For sealing skull base defects or providing bulk.
3. Patient Journey:
    - Preparation: Extensive pre-op planning (imaging, cardiac tests) and a multidisciplinary tumor board review.

- Surgery: Long operation, often with a temporary tracheotomy (breathing tube) and feeding tube.
- Recovery: 1-2 days in ICU, ~7-10 total days in hospital, followed by potential rehab. Full healing takes weeks to months.

## Significance

This technique represents the pinnacle of reconstructive surgery. It moves beyond simple wound closure to functional restoration by transplanting composite, vascularized tissues that can heal, resist infection, and withstand radiation. It is a life-changing intervention for patients with devastating defects, aiming to return them to a functional, social, and dignified life.

**Conclusions/action items:** Microvascular reconstruction is a biological and engineering solution that uses the body's own "spare parts" to rebuild complex facial structures after major cancer surgery, offering patients the best chance at a near-normal appearance and function.

# 2025/09/10- A miniaturized 3D printed pressure regulator (µPR) for microfluidic cell culture applications

ANA CLARA TOSCANO - Sep 10, 2025, 5:40 PM CDT

**Title:** A miniaturized 3D printed pressure regulator (µPR) for microfluidic cell culture applications

**Date:** 2025/09/10

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine Competing Designs and Deepen understanding of the problem

**Content:**

- Microfluidic flow control: displacement-based or pressure controlled techniques

- Product Specification: tunable, 3D printed micro pressure regulator (µPR)

- Function: provide robust flow control capabilities when combined with a battery-powered miniature air pump

The authors highlight several existing methods and their drawbacks:

1. **Displacement-based pumping schemes**:
    - **Syringe pumps** use mechanical screws for controlled fluid dispensing.
    - **Peristaltic pumps** use cam mechanisms to move fluids through tubing.
    - **Advantages:** These pumps offer robust flow control and compatibility with standardized components.
    - **Disadvantages:** They are challenging to integrate into confined environments like incubators, and their mechanical oscillations can cause flow pulsations, potentially damaging cells.
2. **Pneumatic pumping schemes**:
    - These create a defined pressure drop across microfluidic networks to control flow.
    - **Advantages:** They are less prone to flow pulsations due to their intrinsic damping nature.
    - **Disadvantages:** They typically require complex peripheral equipment, such as dedicated high-pressure air sources, closed-loop pressure controllers, back-pressure regulators, and in-line pressure/flow sensors, making integration into confined cell culture environments difficult.
3. **Advanced flow functionalities:** Both displacement and pneumatic techniques can be programmed for dynamic flow profiles (e.g., ramped, periodic, pulsed, reversed). However, these advanced features are often unused in standard microfluidic applications where a constant flow rate is sufficient.
4. **Commercial solutions:**
    - A **commercial palm-top refillable iPrecio infusion pump** exists for cell culture, but it is expensive, single-use, and not customizable.
    - General **commercial pneumatic pressure regulators** typically have larger footprints (>30 mm), higher outlet pressure ranges (~35 kPa) with lower resolution (>3.5 kPa), are not customizable, are expensive (over $100 USD), and require dedicated laboratory compressed air lines.
5. **Passive pumping methods:** Including hydrostatic and surface tension-based approaches.
    - **Advantages:** They are low-cost and easy to use.
    - **Disadvantages:** They lack the long-term stability needed for microfluidic culturing applications lasting over 24 hours.
6. **Microelectromechanical systems (MEMS) micropumps:** While capable of long-term control, their complex fabrication procedures make customization and implementation impractical.

## Technology Deep Dive: The µPR - Useful for PDS

The miniaturized 3D printed pressure regulator (µPR) is proposed as a **tunable, 3D printed solution** for robust, stable, and simplified flow control in microfluidic applications, particularly for cell culture in confined environments.

**1. Purpose and Mechanism:** The µPR provides a tunable output pressure range (1–10 kPa) by utilizing a **force-balance mechanism**. It reduces the high-pressure air supplied by a battery-powered miniature air pump to a controllable, lower pressure relevant for microfluidic systems. This allows for defined flow rates suitable for applications like continuous cell perfusion.

**2. Design and Components:** The µPR is composed of three main structural components, along with sealing and control elements:

- **High-pressure air chamber:** This chamber receives a constant high-pressure air supply from an external miniature air pump. It includes a poppet valve, a connecting rod, and non-adjustable **closing (bottom) cantilever springs** that contribute to an upward closing force (FC). A Viton fluoroelastomer O-ring is fitted over the connecting rod for sealing.
- **Low-pressure air chamber:** This chamber is where the regulated outlet pressure (Pout) is generated. It houses a **pressure sensing diaphragm** (a 100-µm thick Kapton sheet). A natural rubber O-ring is placed in the outer groove of the inlet chamber, and another O-ring is placed on top of the diaphragm for sealing.
- **Pressure control component:** This consists of **3D printed top cantilever springs** (0.5 mm wide, 0.5 mm thick, 5 mm long) and a **control knob**. The control knob is an M2 bolt threaded into an M2 nut, which is glued to the top cantilever springs. A 3D printed pointer is added to the bolt head, and a laser-cut, 24-position acrylic dial provides 15˚ rotational increments.
- **Assembly:** 3D printed clamps are used to compress the outer O-rings and complete the airtight assembly. The final assembled device is **miniaturized**, measuring 12 mm in diameter and 20 mm in height.

**3. Fabrication Process:** The structural components of the µPR are **3D printed** using a Formlabs Form 2 stereolithography printer. Dental SG resin, chosen for its gas-impermeable characteristics and Class I biocompatibility, is used as the building material. After printing, parts are rinsed with isopropyl alcohol, dried, and UV-cured. The use of 3D printing enables **rapid prototyping, low access costs, and customization**, simplifying the creation of complex features like undercuts and cantilever springs that are difficult with conventional methods.

**4. Operation in Four Phases:** The µPR's operation is based on a delicate balance of forces:

- **Phase 1 (Closed):** High-pressure air enters the high-pressure chamber. The constant inlet pressure force (Fin) and the constant upward force from the bottom cantilever springs (FC) push the poppet valve against its seat, closing the air passage.
- **Phase 2 (Top Cantilevers Displaced):** Turning the control knob clockwise increases the bolt's length, displacing the top cantilever springs upwards. This generates a downward restoring force (FT). At this stage, FT is still less than Fin + FC, so the air passage remains sealed.
- **Phase 3 (Air Passage Opens):** Further rotation of the knob increases FT, overcoming Fin + FC. The bolt tip pushes the sensing diaphragm and connecting rod downward, unseating the poppet valve and opening the air passage. High-pressure air then flows into the low-pressure chamber. The increasing outlet pressure (Pout) in this chamber exerts an upward force (Fout) on the diaphragm.
- **Phase 4 (Pressure Regulated/Passage Closes):** Pout rises until Fout combined with Fin and FC equals FT (FT = Fout + Fin + FC). This balance pushes the poppet valve back towards its seat, blocking airflow and maintaining Pout at the desired setpoint. If Pout drops due to downstream flow, the µPR cycles between Phase 3 and Phase 4 to restore the setpoint. The closing cantilever springs in the poppet valve also ensure a "normally-closed" design, allowing users to shut off output pressure.

**5. Control, Tuning, and Performance:**

- **Tunable Range:** The µPR provides a tunable output pressure range of 1–10 kPa.
- **Control Knob:** The angular position of the control knob directly adjusts the displacement (ΔXT) of the top cantilever springs, thereby controlling the restoring force (FT) and, consequently, the outlet pressure (Pout).
- **Calibration:** Due to potential dimensional errors in 3D printed structures, each µPR needs calibration to establish the precise relationship between knob position and output pressure. Calibration revealed two distinct slopes in pressure change per 15° increment, likely due to the compressibility and detachment of the sealing O-ring on the poppet valve.
- **Stability:** When connected to a miniature battery-powered air pump, the µPR demonstrated stable output pressures over five days, with errors of 1.1% at 1.1 kPa, 2.2% at 5.2 kPa, and 1.9% at 10.2 kPa.
- **Flow Rates:** It effectively controls liquid flow rates from 8.50 to 98.7 nL min−1 for pressure drops of 1 to 8 kPa, showing excellent correlation (R2 = 0.999) with COMSOL simulations.
- **Dynamic Control:** The µPR can dynamically ramp pressures up and down to desired setpoints within one-minute periods. Multiple µPRs can be integrated into a single system to control co-laminar liquid flows, demonstrating real-time pressure adjustment and stable dynamic equilibrium positions.

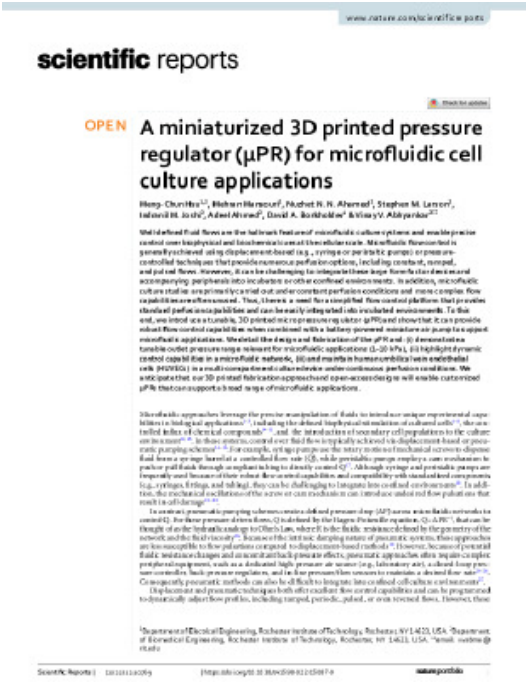
**6. Advantages and Considerations:**

- **Portability and Integration:** Its small footprint (12 mm diameter, 20 mm height) and minimal peripheral equipment requirements (using a miniature battery-powered air pump) make it easily portable and integratable into confined environments like cell culture incubators.
- **Cost-Effective:** The µPR itself costs less than $1.20, and the total setup (including the mini air pump) is less than $7 USD.
- **Customization:** The open-access designs allow for customization, enabling laboratories to tailor µPRs for specific flow requirements by adjusting mechanical parameters like the spring constant (kT) and diaphragm area (Ad).
- **Reusability:** Since the µPR does not come into contact with the fluid, it can be reused multiple times.
- **Limitations:** The µPR is designed for open-ended systems to limit back-pressure effects; complex or closed-end systems might require additional back-pressure regulators, which would necessitate higher driving pressures.

In essence, the µPR acts like a sophisticated, miniaturized faucet for microfluidic systems. Instead of directly turning a handle to control water flow, you turn a knob that adjusts internal springs. These springs, in turn, regulate how much air pressure is released from a constant high-pressure source, much like a household pressure regulator ensures your taps don't blast water at full mains pressure. This allows for precise, stable, and tunable control over fluid flow in tiny channels, overcoming the bulkiness and complexity of traditional microfluidic pumps.

**Conclusions/action items: Have a group discussion of the limitations and about the existing methods.**

ANA CLARA TOSCANO - Sep 10, 2025, 5:20 PM CDT



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A miniaturized 3D printed pressure regulator (µPR) for microfluidic cell culture applications

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# 2025/09/10 - Novel multi-way microvalve with ease of fabrication and integration for microfluidics application

ANA CLARA TOSCANO - Sep 11, 2025, 9:11 PM CDT

**Title:** Novel multi-way microvalve with ease of fabrication and integration for microfluidics application

**Date:** 2025/09/10

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine Competing Designs and Deepen understanding of the problem

**Content:**

Competing Design Approaches for Microfluidic Flow Control and Valves

Microfluidic systems require precise fluid flow control, typically achieved through displacement-based or pressure-controlled techniques. However, many existing methods face challenges in fabrication, integration, and performance:

1. **Displacement-based pumping schemes** (e.g., syringe and peristaltic pumps): These offer robust flow control and compatibility with standard components. However, they are often bulky, making them difficult to integrate into confined environments like incubators. Their mechanical oscillations can also introduce flow pulsations, potentially harming cells.
2. **Pneumatic pumping schemes**: These create a defined pressure drop for flow control and are less prone to pulsations due to their intrinsic damping. However, they often require complex peripheral equipment, such as dedicated high-pressure air sources, closed-loop pressure controllers, back-pressure regulators, and in-line sensors, making integration difficult in confined cell culture settings. Commercial pneumatic regulators also typically have larger footprints (>30 mm), higher outlet pressure ranges (~35 kPa) with lower resolution (>3.5 kPa), are expensive (>$100 USD), and are not customizable.
3. **Traditional microvalves (e.g., Quake's valve)**: These often involve multi-layer polydimethylsiloxane (PDMS) structures, requiring high-precision alignment during fabrication. Similar challenges apply to SMA (Shape Memory Alloy) valves and 3D-printed Quake-style valves, which still necessitate complex multi-layer designs and high-precision alignment.
4. **Liquid metal-based valves (earlier attempts)**: Some early designs relied on mechanical strength changes from alloy state changes via temperature regulation, acting as one-shot valves that were not sufficiently soft or required multi-layer structures. Others utilized solidification and melting of low-melting alloys, increasing response time and still requiring multi-layer alignment. Electrostatic liquid metal valves also required alignment and used less flexible, more costly ITO (Indium Tin Oxide). While liquid metal microfluidic elements like heaters, sensors, and electroosmotic pumps have been developed, a fundamental "liquid metal-based microvalve" was missing for on/off control and fluid direction.
5. **3D-printed radial compression rotor-stator valves**: In these designs, the cylinder jacket surface of the rotor acts as the sealing surface, and tightness is achieved by selecting the appropriate fit during manufacturing. However, the rough surface of 3D-printed parts can lead to small gaps and immediate leakage without specific sealing elements or post-processing. Lubricants, Teflon sprays, or elastic PDMS stators are often required to ensure sealing.
6. **Commercial axial compressed valves**: While reliable and featuring axial compression, these valves are often integrated into 3D-printed chips "as is," limiting design customization and not fully exploiting the potential of 3D printing.

## Deep Dive into Novel Multi-Way Microvalve Technologies

1. Liquid-Metal-Enabled Microvalve (Gong et al.)

This work proposes a **room-temperature liquid metal-based microvalve** with advantages in **easy fabrication, high flexibility, and a low leak rate**, primarily for on-chip fluid control.

- **Ease of Fabrication and Integration:**
    - **Simplified Fabrication:** A key advantage is that this microvalve **avoids the complex alignment process** typically required for multi-layer microvalves like Quake's valve, significantly increasing the success rate of chip fabrication.
    - **Total Soft Metal Microvalve:** It consists solely of liquid metal and polydimethylsiloxane (PDMS), without requiring phase transitions. This makes it suitable for integration into **wearable devices** due to its softness and flexibility.
    - **Single-Layer Structure:** The microvalve can be designed and fabricated simultaneously with the sample channel on the **same chip layer**, overcoming the complexities of traditional multi-layer microvalve structures.

- **Design and Components:**
    - The microvalve chip features a **two-layer structure** made of PDMS. The upper layer contains a "T"-shaped microchannel (50 µm high), while the lower layer serves as a flat base.
    - The channels are arranged such that a **vertical channel** (0.5 cm long, 300 µm wide) acts as the liquid metal flow path, and a **horizontal channel** (2 cm long, 300 µm wide) is for the fluid sample.
    - A critical feature is the **posts array** – two columns of juxtaposed, equally spaced **PDMS posts** positioned at the intersection of the liquid metal and fluid sample channels. These posts (isosceles trapezoidal, 25 µm upper base, 40 µm lower base, 25 µm height, 18 µm minimum gap) are designed to **prevent liquid metal from entering the fluid sample channel** and help form a deformable "valve boss" or "liquid metal tongue". Different inclination angles (30°, 45°, 60°, 75°, and 90°) were studied for their effect on performance.
    - The valve material is **Ga66In20.5Sn13.5 liquid metal**, which is nontoxic, has a low melting point (10.6 °C), good flowability, and high surface tension, allowing it to block flow effectively.
- **Fabrication Process:**
    - The microvalve chips are fabricated using **standard soft lithography**.
    - An SU-8 2050 mold for the T-shaped channel (50 µm height) is created on silicon wafers.
    - PDMS (Sylgard 184, 10:1 ratio) is cast onto the mold, cured at 65 °C for 2.5 hours, and peeled off.
    - The channel-containing PDMS slab is then **plasma bonded** with a plain PDMS slab (2 mm thick) and baked at 95 °C for 10 minutes to complete the chip fabrication.
- **Device Operation:**
    - **Closing:** Initially, the entire channel is filled with DI water, meaning the valve is open. To close, liquid metal is pumped into the vertical channel. Its high surface tension ensures it fills the vertical channel without leaking into the sample path, effectively **blocking the fluid sample flow**. A liquid metal pressure of 400 mbar was used for reliable closing.
    - **Opening:** To reopen, the liquid metal pumping pressure is reduced (e.g., from 400 mbar to 100 mbar), and the sample pumping pressure is simultaneously increased (e.g., 100–200 mbar). The combined force of the sample fluid pressure and the liquid metal's tension forces the liquid metal to retract to the vertical channel, **opening the fluid path**.
- **Performance and Improvements:**
    - **Repeatability Enhancement:** Liquid metal is prone to oxidation, forming $Ga_2O_3$, which strongly adheres to PDMS surfaces, hindering repeatability. To combat this, **electrochemical cathodic protection** is applied. By connecting the liquid metal inlet to the cathode and the DI water outlet to the anode (-800 V), water electrolysis produces hydrogen, which mechanically strips oxides and creates an acidic environment to prevent further oxidation.
    - **Switch Cycles:** With -800 V cathodic protection, the **30° angle microvalve achieved up to 145 on/off switch cycles**. Valves with larger angles showed significantly lower repeatability, with the 90° valve being almost non-repeatable due to the perpendicular flow hindering liquid metal retraction.
    - **Leak Rate:** The valve demonstrated **excellent anti-leakage characteristics**, with no detected leakage at ≤320 mbar when closed, and a leak rate of ≤0.043 µL/min at 330 mbar.
    - **Burst Pressure:** It exhibited a maximum burst pressure of 390 mbar (for the 75° valve at 400 mbar liquid metal pressure), indicating good shock resistance.
    - **Response Time:** The average opening time for a 30° valve was 9.2 s, and closing was 3.0 s.
- **Applications:** The microvalve was successfully demonstrated in **controlling bubble flow direction** within a Y-shaped microfluidic channel. Its design also makes it suitable for controlling various water-based microflows, droplets, particles, or cells, and its softness and single-layer structure lend it to potential **wearable device applications**.

2. Configurable 3D Printed Microfluidic Multiport Valves with Axial Compression (Diehm et al.)

This paper introduces a **configurable 3D-printed microfluidic multiport valve utilizing axial compression**, a common design in commercial valves, to enhance performance and configurability in 3D-printed systems.

- **Ease of Fabrication and Integration:**
    - **Axial Compression Advantage:** Unlike radial compression designs where a precise fit is crucial, axial compression allows for **adjustable compression** and easier integration of various materials and **external sealing elements**. This simplifies manufacturing as precise fit is less critical.

    - **Full 3D Printing Potential:** By making both the rotor and stator 3D-printable, the design allows for **direct integration of merges, diverges, and mixers** into the valve components, thereby minimizing dead volume and increasing configurability. This fosters "lab-on-valve" applications where the valve is designed specifically for the application.
    - **Transferability:** The design approach is **transferable to different 3D printing methods and materials without requiring design changes** or preliminary fit/tolerance tests.
    - **Economic Efficiency:** 3D printing offers **high economic efficiency**, especially for prototyping complex microfluidic chips.

- **Design and Components:**

    - The valve comprises three fundamental parts: a **stator, a rotor, and a cover**, which are compressed axially by screws.
    - All internal flow channels were designed with a **diameter of 800 µm**.
    - **Six different sealing concepts** were evaluated to address the inherent roughness of 3D-printed surfaces:
        - Initial concepts without external sealing or with polishing alone (Concepts 1 and 2) **leaked immediately**, regardless of printing technique, due to surface roughness.
        - Concepts using **external sealing elements** (silicone mats, O-rings, or 3D-printed sealing mats) were all **tight up to at least 15 bar** in static tests.
        - **Concept 5 (silicone mat covering the rotor sealing area and an O-ring in a stator groove)** demonstrated the **best performance for long-term applications** due to superior wear resistance compared to concepts relying solely on O-rings on rough printed surfaces.
        - Concept 6 (DLP-printed sealing mats with integrated o-ring-like structures) showed similar promising performance but was not scaled up due to printer size limitations.
    - An **upscaled valve** based on Concept 5, with 8 intravalve connections and a 2.7-times larger sealing area, maintained identical performance and **showed no leakage after 50 dynamic rotations**.

- **Fabrication Process:**

    - Valve designs are created using CAD software (Inventor Pro 2020) and exported as .stl files for printing.
    - **Polyjetting** (Object EDEN 360V with VeroClear resin and SUP705 support material) and **DLP printing** (ASIGA Max X35 with BV-007 microfluidic resin) were used.
    - Printed parts undergo cleaning to remove support material (mechanically, then chemically with NaOH for polyjetting, or isopropyl alcohol for DLP) and UV post-curing.
    - **1/4-28" UNF threads are drilled** after printing for robust external fluid connections with flangeless fittings, proving more durable than directly printing them. Sealing mats are adhered using epoxy.

- **Device Operation and Performance:**

    - **Sealing Performance:**
        - **Static:** Concepts with additional sealing elements (3-6) were effective up to at least 15 bar.
        - **Dynamic:** The most promising designs (4, 5, 6) showed unchanged tightness after 5 rotations. Concept 5, with its O-ring and silicone mat, exhibited superior reusability and wear resistance for long-term use.
        - **Leakage:** In dynamic tests with continuous flow, leakage was minimized at a **torque of 30 Ncm**, averaging **0.15% (0.15 µL/min)**, which is comparable to commercial valves. Leakage was found to occur primarily **during the switching process**, not statically, and was generally below 0.5% – considered small for most applications.
    - **Automated Operation:** The system can be **automatically turned with a stepper motor**, allowing for precise control and optimization of axial compression to achieve optimal sealing without compromising positioning accuracy.
    - **Flow Source Interplay:** Performance was comparable to a commercial Äkta column valve system, with similar mean leakage values (0.2–0.35%) within measurement accuracy. While the 3D-printed valve showed sporadic leakage during switching due to manufacturing tolerances, this is at a very low level and could be mitigated by pausing the pump during switching.

The configurable 3D-printed multiport valve with axial compression offers **customization and robust sealing** through external elements and adjustable compression, while the liquid-metal-enabled microvalve provides **extreme simplicity in fabrication** by eliminating complex alignment and multi-layer structures. Both represent significant advancements in making microfluidic valves more accessible and adaptable for various applications.

**Conclusions/action items: T**hese designs aim to overcome the limitations of traditional microvalves and existing flow control methods, particularly regarding complexity, cost, and integration into compact systems.

ANA CLARA TOSCANO - Sep 10, 2025, 7:10 PM CDT



Sensors and Actuators B: Chemical

Volume 286, 1 May 2019, Pages 289-300

**Novel multi-way microvalve with ease of fabrication and integration for**

# 2025/09/15 - Configurable 3D Printed Microfluidic Multiport Valves with Axial Compression

ANA CLARA TOSCANO - Sep 15, 2025, 8:30 PM CDT

**Title:** Configurable 3D Printed Microfluidic Multiport Valves with Axial Compression

**Date:** 09/15/2025

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine competing Designs for Valves

**Citation:**

Diehm, J., Hackert, V., & Franzreb, M. (2021). Configurable 3D Printed Microfluidic Multiport Valves with Axial Compression. *Micromachines*, *12*(10), 1247. https://doi.org/10.3390/mi12101247

**Content:**

**Designing and Controlling Branching Architectures:**

◦ A primary competitive advantage is the ability to **integrate 3D printable components like merges, diverges, and mixers directly into the stator as well as the rotor**. The integration of merges and diverges is fundamental for creating and managing branching fluid paths within a bioprinting system.

◦ The system can be **turned automatically with a stepper motor**, allowing for precise and automated control over switching operations, which is vital for complex branching sequences and flow regulation.

**• Shutoff Valve Functionality and Flow Control:**

◦ The valve demonstrates excellent tightness, with **no measurable leakage for the static case and leakages below 0.5% in the dynamic case**. This reliability is paramount for any "shutoff valve" function and for maintaining "highly controlled flow". The best long-term performance was achieved using a combination of **O-rings and a silicone sealing mat** as external sealing elements.

◦ The axial compression design allows for **adjustable compression**, meaning the sealing force can be fine-tuned or adapted to wear, contributing to robust and consistent flow control over time.

**• Addressing Different Vessel Sizes (1 mm range):**

◦ The flow channels within these valves had a diameter of **800 µm** in test configurations. While this technology doesn't *print* the vessels, it can effectively manage and direct fluid flow *through* channels of this approximate diameter.

**• Scalability and Versatility:**

◦ The valve is **easy to scale up** regarding the sealing surface and the number of channels. This modularity offers flexibility for designing bioprinters capable of handling diverse and extensive vascular networks.

◦ The approach is **transferable to other printing methods and materials without design changes**. This broad applicability allows for integration with various bioprinting materials and techniques you might employ.

◦ The valves are capable of handling pressures up to **15 bar**, indicating robust operation for applications requiring significant fluid pressure.

**Conclusions/action items:** This technology is customizable flow control capabilities for branching architectures and ability to manage flows in millimeter-scale channels make it a strong competitor in the broader field of microvascular channel bioprinting and flow regulation.

# 2025/09/15 - Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

ANA CLARA TOSCANO - Sep 15, 2025, 8:51 PM CDT

**Title:** Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

**Date:** 09/15/2025

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine the Applications of sheet -based bioprinting

**Citation:**

Hooper, R., Cummings, C., Beck, A., Vazquez-Armendariz, J., Rodriguez, C., & Dean, D. (2024). Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications. *Biofabrication*, *16*(2), 025032. https://doi.org/10.1088/1758-5090/ad30c8

**Content:**

The CEVIC device is a novel, patent-pending multi-material technology that aims to overcome limitations of traditional extrusion bioprinting by extruding **thin, wide cell-laden hydrogel sheets instead of filaments**. This approach allows for the production of a complete micropatterned construct over a large area in a single extrusion.

Here's how the CEVIC device directly competes with your prototype's problem statements:

• **Branching Channels and Printing Complex Architectures:** The CEVIC device is specifically designed to produce **hierarchical branching channels**. It can create **continuous gradients varying geometry and materials** across the construct, which is crucial for mimicking natural microvascular networks. The technology is explicitly stated as the "first attempt at modulating channel number and width mid-extrusion throughout a chaotically-printed construct for the purposes of replicating the hierarchical branching pattern of native microvasculature with accurate dimensions". This directly addresses your "idea of branching channels" and the goal to "design device so flow is highly controlled to print branching architecture" [Query].

• **Adding Sequential Elements to Double Layers to KSM:** The CEVIC device adapts **chaotic printing principles** and utilizes **Kenics Static Mixers (KSMs)**. It leverages the property that the number of internal layers or channels doubles with each KSM element added in sequence (s = 2^n). The CEVIC device can **switch between KSMs mid-extrusion** to create variations in channel number and thickness within a continuous sheet, effectively allowing for the addition of sequential elements to double layers. This directly corresponds to your problem of "Can add sequential elements to double number of layers to KSM" [Query].

• **10-30 Micron Size Critical for Capillaries:** A significant competitive advantage of the CEVIC device is its demonstrated ability to produce channels with **average widths ranging from 621.5 ± 42.92% µm down to 11.67 ± 14.99% µm**. The smallest measured channel width was **10 µm**, accurately encompassing the critical size range for capillaries. This high resolution is achieved without requiring smaller nozzle diameters, thus avoiding issues like clogging and increased shear stress that can compromise cell viability.

• **Need for Big Blood Vessels (Order of 1 mm):** The CEVIC device's capability to produce channels with widths spanning from **artery diameter-scale (~1–6 mm)** down to capillary-scale (~10 µm) addresses the need for both large and small vessels within a single bioprinted construct. The average width of 8-channeled sheets was 621.5 µm, which falls within the approximate 1 mm range required for suturing to existing host vasculature.

• **Issues When Switching/Branching Between K Mixers & Fluid Flow Control:** The CEVIC device explicitly "adapts the chaotic printing approach to control the width and number of microchannels within the construct as it is extruded (i.e. on-the-fly)". It can **switch between materials/bioinks and Kenics mixers mid-extrusion** through a single printhead. This direct control over switching and micropatterning during extrusion provides a

mechanism to analyze and manage fluid flow within the device and its relation to the printed architecture, directly addressing your concern about "issues when switching/branching between K mixers" and the need for "highly controlled flow" [Query].

• **Perfusability and Cell Viability:** The CEVIC device can incorporate **fugitive/sacrificial inks** that diffuse out after printing, leaving behind **vacant, perfusable channels**. Experiments demonstrated the perfusability of these channels by injecting dyed water, which flowed through and exited the constructs. Furthermore, co-cultures of microvascular cell types (endothelial cells and pericytes) in CEVIC-produced hydrogel constructs maintained **over 90% viability** for at least a week, indicating its suitability for creating living vascularized tissues.

**Conclusions/action items:**

# 2025/09/15 - A Novel On-Chip Liquid-Metal-Enabled Microvalve

ANA CLARA TOSCANO - Sep 15, 2025, 10:41 PM CDT

**Title:** A Novel On-Chip Liquid-Metal-Enabled Microvalve

**Date:** 09/15

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine limitations of a novel valve technology

**Citation:**

Gong, J., Wang, Q., Liu, B., Zhang, H., & Gui, L. (2021). A Novel On-Chip Liquid-Metal-Enabled Microvalve. *Micromachines*, *12*(9), 1051–1051. https://doi.org/10.3390/mi12091051

**Content:**

This technology introduces a room-temperature liquid metal-based microvalve designed for **controlling microfluidic motion**.

Here's a breakdown of how it competes with your prototype's problem statements:

**• Controlling Branching Channels and Highly Controlled Flow:**

◦ The microvalve is capable of **controlling the direction of fluid flow**, demonstrated by its application in manipulating **bubble flow in a Y-shaped channel**. This directly addresses the need for controlling flow in branching architectures. The system allows for the on/off switch of fluid channels and fluid flow direction.

◦ It offers **highly controlled flow** due to its design for reliable switching commands and a **low leak rate**. No leak is detected at pressures up to 320 mbar, and at 330 mbar, the leak rate is ≤0.043 µL/min. This tightness is crucial for precise flow management.

◦ The valve's operation involves adjusting pressure to the liquid metal to open or close the flow path, allowing for controlled fluid manipulation.

**• Shutoff Valve Functionality:**

◦ The liquid metal (GaInSn) forms a **deformable valve boss** that effectively blocks the flow path when closed. This directly competes with the shutoff valve requirement of your prototype.

◦ To improve reliability, an **electrochemical cathodic protection method** is used to eliminate issues with liquid metal oxidation, significantly increasing the number of open/close switch cycles up to **145 for the 30° angle valve**. This addresses the need for repeatable switching.

**• Relevance to Small (10-30 micron) and Large (1 mm) Vessel Sizes:**

◦ The device incorporates **PDMS posts** with a **minimum gap of 18 µm** between them. This internal feature size demonstrates the ability to manage or operate at a scale relevant to capillaries.

◦ However, the main **fluid sample flow path** within the microvalve is **300 µm wide**. This dimension is smaller than the 1 mm scale you need for suturing to existing blood vessels. While it can control microflows, it is not designed to *create* or handle the larger flow volumes of millimeter-sized vessels.

**Conclusions/action items:**

Areas where it does not meet prototype requirements or has limitations:

**• No KSM Integration or Layer Doubling:** The design and function of this microvalve **do not involve Kenics Static Mixers (KSMs)**, nor does it address the concept of adding sequential elements to double the number of layers or issues related to switching/branching between K mixers.

# 2025/12/10 - 3D nanoprinting of PDMS microvessels with tailored tortuosity and microporosity via direct laser writing

ANA CLARA TOSCANO - Dec 10, 2025, 5:11 PM CST

**Title:** 3D nanoprinting of PDMS microvessels with tailored tortuosity and microporosity via direct laser writing

**Date:** 2025/12/10

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine the applicability of a nanoprinting competing design

Citation:

Xu, X., Qiu, Y., Chen, C.-Y., Carton, M., Campbell, P. M. R., Chowdhury, A. M., Bandyopadhyay, B. C., Bentley, W. E., Smith, B. R., & Sochol, R. D. (2025). 3D nanoprinting of PDMS microvessels with tailored tortuosity and microporosity *via* direct laser writing. *Lab on a Chip*, *25*(8), 1947–1958. https://doi.org/10.1039/d4lc01051e

**Content:**

The method combines two additive manufacturing techniques:

1. Macro/Micro-Scale Base: Liquid-Crystal Display (LCD) 3D printing rapidly creates a sturdy microfluidic chip with integrated fluidic ports.
2. Micro/Nano-Scale Vessels: Ex Situ Direct Laser Writing (esDLW) then nanoprints complex, free-form PDMS microvessels directly on top of the chip's ports. This bypasses the height restrictions of printing inside enclosed channels.

## Key Achievements

- Fabrication: Successfully created 100 µm-diameter PDMS microvessels with 5 µm-thick walls containing designed 5 µm micropores, as well as three fully intertwined, spiraled microvessels.
- Functionality:
    - The vessels withstood high burst pressures (up to 100 kPa) without leaking or detaching.
    - Extravasation studies demonstrated precise control of fluid flow through the micropores by tuning input and outlet pressures.
    - The PDMS microvessels supported cell culture, with MDA-MB-231 breast cancer cells adhering and remaining viable on the inner lumen for 24 hours.

## Significance & Potential

This work provides a new manufacturing pathway for Organ-on-a-Chip (OOC) systems. The ability to independently design vessel tortuosity (3D path) and microporosity (wall permeability) at biologically relevant scales could enable more accurate models for studying processes like:

- Cancer metastasis (extravasation/intravasation)
- Drug delivery and screening
- Personalized medicine
- Disease modeling (e.g., of the blood-brain barrier)

**Conclusions/action items:** The strategy offers superior geometric versatility compared to conventional soft lithography or extrusion-based 3D printing, moving beyond planar or semi-circular channels to create truly 3D, free-form, and interconnected vascular networks.

# 2025/09/11- Design and Characterization of an Adjustable Passive Flow Regulator and Application to External CSF Drainage

ANA CLARA TOSCANO - Sep 11, 2025, 9:27 PM CDT

**Title:** Design and Characterization of an Adjustable Passive Flow Regulator and Application to External CSF Drainage

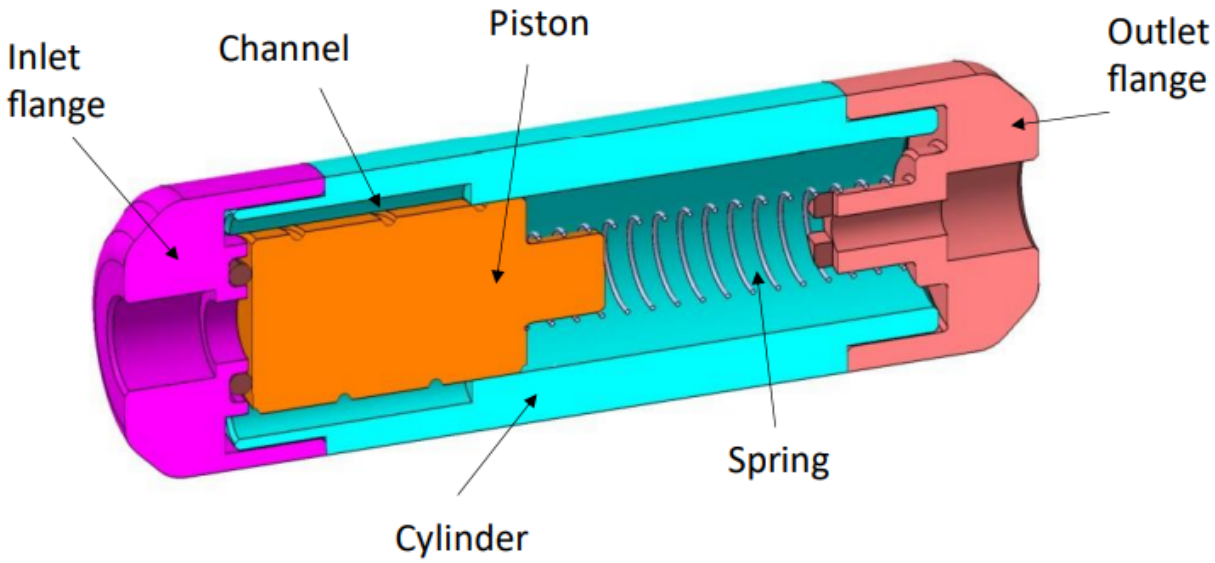
**Date:** 09/11/2025

**Content by:** Ana Clara Toscano

**Present:** Ana Toscano

**Goals:** Determine Standards for Product Design Specification

**Content:**




## 1. ISO 3 Water (Test Medium Standard)

- **Reference**: Section 2.6, "Fluidic Characterization"
- **Meaning**: Water ISO 3 is used as the **test fluid** to ensure repeatability and comparability across tests.
- **Purpose**: ISO 3 grade water refers to **high-purity laboratory water** with controlled contaminants and conductivity.
- **Use in study**: This ensures that fluidic resistance measurements are **not influenced by impurities**, mimicking cerebrospinal fluid (CSF) conditions.

### 2. Fluidic Resistance Measurement Protocols

- **Standard practice**: Use of **pressure steps** (e.g., 5 and 10 mbar) and controlled **flow measurement intervals** (30 seconds).
- **Measurement instrumentation**: Includes **Druck DPI520 pressure controller** and **Sartorius MC1 LP620P scale**—both used in **ISO-compliant calibration** environments.
- **Purpose**: Ensures data meets **repeatability and traceability standards**, often required under general ISO 9001 (quality management systems) or **ISO/IEC 17025** (testing/calibration labs).

**Conclusions/action items: Update standard to Product Design Specification.**

# 2025/09/12 - Notes from Client Meeting Recording

ANA CLARA TOSCANO - Sep 12, 2025, 10:12 AM CDT

**Title: Notes from Client Meeting Recording**

**Date:** 2025/09/12

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Determine important client requirements

**Content:**

Focus: Branching architecture that controls the flow - create blood vessels that reach down to capillary scale - current gap in field

Impact: Every cell needs to be 50-70 microns of a vascular channel

Idea they have in mind: Vascular sheets is good because we can wrap around

**Conclusions/action items: Schedule weekly meetings with Josh and one with the student the client mentioned worked directly with the problem we are addressing.**

# 2025/09/25 - Design Matrix Ideas Summarized

ANA CLARA TOSCANO - Dec 10, 2025, 6:00 PM CST

**Title: Design Brainstorming**

**Date:** 09/25

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Elaborate in design

**Content:**

1. Clamps above

2. a disk that rotates with holes so we can control what is going

3. flow diversion system

| *Criteria (weight)* | Concept A: Clamp | | Concept B: Internal Rotated Element | | Concept C: Flow Diversion System | |
|---|---|---|---|---|---|---|
| *Maintain Pattern & Resolution (25)* | *5/5* | 25 | *4/5* | 20 | *4/5* | 20 |
| *Automatable (20)* | *3.5/5* | 14 | *5/5* | 20 | *4/5* | 16 |
| *Durability (15)* | *3/5* | 9 | *3/5* | 9 | *3/5* | 9 |
| *Ease of Fabrication (15)* | *4/5* | 12 | *4/5* | 12 | *3/5* | 9 |
| *Workflow Maintenance (15)* | *4.5/5* | 13.5 | *3/5* | 9 | *4.5/5* | 13.5 |
| *Safety (5)* | *4.5/5* | 4.5 | *5/5* | 5 | *4.5/5* | 4.5 |
| *Cost (5)* | *4/5* | 4 | *5/5* | 5 | *5/5* | 5 |
| *Total (100)* | **Sum** | 82 | **Sum** | 81 | **Sum** | 77 |

**Conclusions/action items:** The three designs were assessed on seven criteria, with Maintenance of Pattern & Resolution, and Automation.

# 2025/11/03- Design Flow Diversion

ANA CLARA TOSCANO - Dec 10, 2025, 6:06 PM CST

**Title:** Design Flow Diversion

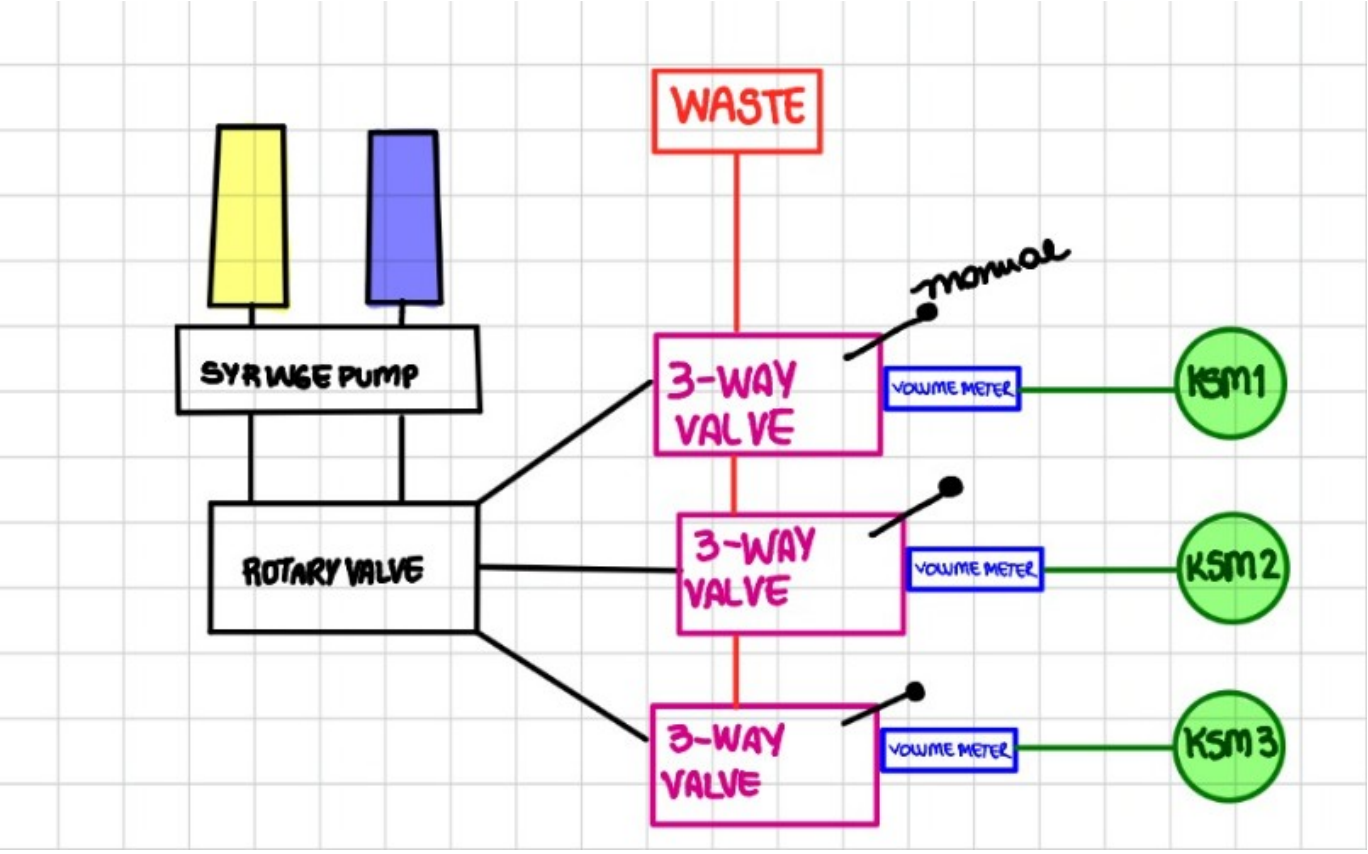
**Date:** 2025/11/03

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Create a design diagram

**Content:**




**Conclusions/action items:** *Design 3 preliminary design sketch*

# 2025/10/28- Fluent Training Protocol

ANA CLARA TOSCANO - Oct 29, 2025, 5:41 PM CDT

**Title: Fluent Training Protocol**

**Date:** 10/28

**Content by:** Ana Toscano

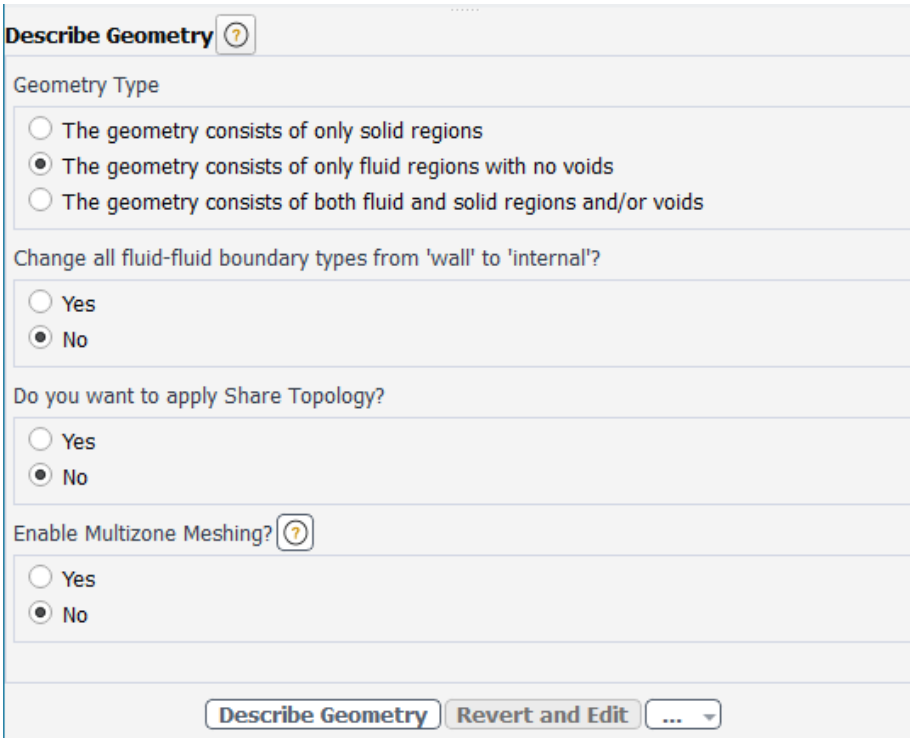
**Present:** Ana Toscano

**Goals:** Protocol for learning how to create velocity simulations Fluent

**Content:**

**Problem Description:** A cold fluid at 20° C flows into the pipe through a large inlet, and mixes with a warmer fluid at 40° C that enters through a smaller inlet located at the elbow. The pipe dimensions are in inches and the fluid properties and boundary conditions are given in SI units. The Reynolds number for the flow at the larger inlet is 50,800, so a turbulent flow model will be required.

**Some assumptions:**




**Link:** [Chapter 5: Fluid Flow and Heat Transfer in a Mixing Elbow]

**Conclusions/action items: This is a section of the link on how to adapt the mesh, so it is a more simplistic and accurate representation of the design. Note this could be used to test the sheer stress and velocity.**

## 5.4.7. Adapting the Mesh

For the first run of this tutorial, you have solved the elbow problem using a fairly coarse mesh. The elbow solution can be improved further by refining the mesh to better resolve the flow details. Ansys Fluent provides a built-in capability to easily adapt

(locally refine) the mesh according to solution gradients. In the following steps you will adapt the mesh based on the temperature gradients in the current solution and compare the results with the previous results.

1. Define **Cell Registers** to adapt the mesh in the regions of high temperature gradient.

   **Solution** → **Cell Registers** **New** → **Field Variable...**

   a. Select **Cells More Than** from the **Type** drop-down list.

   b. Select **Curvature** from the **Derivative Option** drop-down list.

   c. Select **Temperature...** and **Static Temperature** from the **Curvature of** drop-down list.

   d. Click **Compute**.

      *Ansys Fluent will update the **Minimum** and **Maximum** values to show the minimum and maximum temperature gradient. The **Average** temperature gradient and **Standard Deviation** will also be displayed.*

   e. Enter a value of `0.0015` for the **Cells having value more than**.

      *A general rule is to use about 10% of the maximum gradient when setting the value for refinement.*

   f. Click **Save** and close the **Field Variable Register** dialog box.

2. Set up mesh adaption using the **Cell Registers**. For this task, you will use the **Adapt** group box in the **Domain** ribbon tab.

   **Domain** → **Adapt** → **Manual...**

   a. Select the previously defined **curvature_0** cell register from the **Refinement Criterion** drop-down lists.

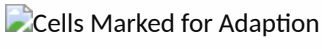
      *Ansys Fluent will not coarsen beyond the original mesh for a 3D mesh. Hence, it is not necessary to select the **Coarsening Criterion** in this instance.*

   b. Click **Adapt**.

   c. Click **Display**.

*Ansys Fluent will display the cells marked for adaption in the graphics window (Figure 5.11: Cells Marked for Adaption).*

**Figure 5.11: Cells Marked for Adaption**




**Extra** — You can change the way Ansys Fluent displays cells marked for adaption (Figure 5.12: Alternative Display of Cells Marked for Adaption) by performing the following steps:

i. Click **Display Options...** in the **Manual Mesh Adaption** dialog box to open the **Display Options - Adaption** dialog box.

ii. Enable **Draw Mesh** in the **Options** group box.

*The **Mesh Display** dialog box will open.*

iii. Ensure that only the **Edges** option is enabled in the **Options** group box.

iv. Select **All** from the **Edge Type** list.

v. Select all of the items except **z=0_outlet** from the **Surfaces** selection list.

vi. Click **Display** and close the **Mesh Display** dialog box.

vii. Click **OK** to close the **Display Options - Adaption** dialog box.

viii. Click **Display** in the **Manual Mesh Adaption** dialog box.

ix. Rotate the view and zoom in to get the display shown in Figure 5.12: Alternative Display of Cells Marked for Adaption.

**Figure 5.12: Alternative Display of Cells Marked for Adaption**


x. After viewing the marked cells, rotate the view back and zoom out again.

xi. Click **Close** to close the **Manual Mesh Adaption** dialog box.

3. Display the adapted mesh (Figure 5.13: The Adapted Mesh).

**Domain → Mesh → Display...**

a. Disable **Faces** in the **Options** group box.

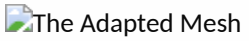
b. Select **All** from the **Edge Type** list.

c. Deselect all of the highlighted items from the **Surfaces** selection list except for **symmetry-xyplane**.

> **Tip:** To deselect all surfaces, click the **Deselect All Shown** button ( ) at the top of the **Surfaces** selection list. Then select the desired surface from the **Surfaces** selection list.

d. Click **Display** and close the **Mesh Display** dialog box.

**Figure 5.13: The Adapted Mesh**


The Adapted Mesh

4. Request an additional 150 iterations.

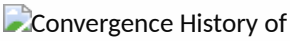
**Solution → Run Calculation → Calculate**

*The solution will converge as shown in Figure 5.14: The Complete Residual History and Figure 5.15: Convergence History of Mass-Weighted Average Temperature.*

**Figure 5.14: The Complete Residual History**


The Complete Residual History

**Figure 5.15: Convergence History of Mass-Weighted Average Temperature**


Convergence History of Mass-Weighted Average Temperature

5. Save the case and data files for the solution with an adapted mesh (`elbow2.cas.h5` and `elbow2.dat.h5`).

**File → Write → Case & Data...**

a. Enter `elbow2.cas.h5` for **Case/Data File**.

b. Click **OK** to save the files and close the **Select File** dialog box.

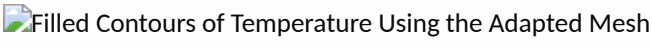
*The files `elbow2.cas.h5` and `elbow2.dat.h5` will be saved in your default folder.*

6. Display the temperature distribution (using node values) on the revised mesh using the temperature contours definition that you created earlier (Figure 5.16: Filled Contours of Temperature Using the Adapted Mesh).

Right-click the **Results/Graphics/Contours/contour-temp** tree item and select **Display** from the menu that opens.

**Results → Graphics → Contours → contour-temp Display**

**Figure 5.16: Filled Contours of Temperature Using the Adapted Mesh**

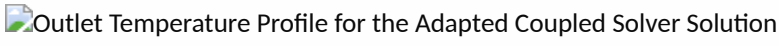

Filled Contours of Temperature Using the Adapted Mesh

7. Display and save an XY plot of the temperature profile across the centerline of the outlet for the adapted solution (Figure 5.17: Outlet Temperature Profile for the Adapted Coupled Solver Solution).

   **Results → Plots → XY Plot → xy-outlet-temp Edit...**

   a. Click **Save/Plot** to display the XY plot.

   **Figure 5.17: Outlet Temperature Profile for the Adapted Coupled Solver Solution**

   
   Outlet Temperature Profile for the Adapted Coupled Solver Solution

   b. Enable **Write to File** in the **Options** group box.

      *The button that was originally labeled **Save/Plot** will change to **Write...**.*

   c. Click **Write...**.

      i. In the **Select File** dialog box, enter `outlet_temp2.xy` for **XY File**.

      ii. Click **OK** to save the temperature data.

   d. Close the **Solution XY Plot** dialog box.

8. Display the outlet temperature profiles for both solutions on a single plot (Figure 5.18: Outlet Temperature Profiles for the Two Solutions).

   a. Open the **Plot Data Sources** dialog box.

      **Results → Plots → Data Sources...**

   b. Click the **Load File...** button to open the **Select File** dialog box.

      i. Select **outlet_temp1.xy** and **outlet_temp2.xy**.

      *Each of these files will be listed with their folder path in the bottom list to indicate that they have been selected.*

      > **Tip:** If you select a file by mistake, simply click the file in the bottom list and then click **Remove**.

      ii. Click **OK** to save the files and close the **Select File** dialog box.

   c. Select the folder path ending in **outlet_temp1.xy** from the **Curve Information** selection list (**Curves** group box).

   d. Enter `Before Adaption` in the lower-right text-entry box.

e. Click the **Change Legend Entry** button.

*The item in the **Legend Entries** list for **outlet_temp1.xy** will be changed to **Before Adaption**. This legend entry will be displayed in the upper-left corner of the XY plot generated in a later step.*

f. In a similar manner, change the legend entry for the folder path ending in **outlet_temp2.xy** to be `Adapted Mesh`.

g. Click **Plot** and close the **Plot Data Sources** dialog box.

*Figure 5.18: Outlet Temperature Profiles for the Two Solutions shows the two temperature profiles at the centerline of the outlet. It is apparent by comparing both the shape of the profiles and the predicted outer wall temperature that the solution is highly dependent on the mesh and solution options. Specifically, further mesh adaption should be used in order to obtain a solution that is independent of the mesh.*

**Figure 5.18: Outlet Temperature Profiles for the Two Solutions**

# 2025/10/28- Documentation Result Simulation (Not adapted yet)

ANA CLARA TOSCANO - Nov 19, 2025, 3:10 PM CST

**Title: First Draft - Simplified Geometry Documents**

**Date:** 2025/10/28

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Create a starting point for fluent ANSYS simulation

**Content:**

**Attached are 8 files (mesh, temperature average, velocity)**

**Conclusions/action items: Not totally confortable with the assumptions I made so I am now looking at some parameters from the system like viscosity so I can support my assumptions. A second draft will be created.**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT


Download

**elbow.msh.h5 (2.7 MB)**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT


Download

**outlet-temp-avg-rfile.out (668 B)**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT


Download

**elbow.sf (98.8 kB)**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT

Download

**elbow.wft (8.32 kB)**

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**TaskObject11.msh.h5 (440 kB)**

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**TaskObject3.msh.h5 (234 kB)**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT

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**elbow.cas.h5 (3.01 MB)**

ANA CLARA TOSCANO - Oct 29, 2025, 5:43 PM CDT

Download

**elbow.dat.h5 (2.96 MB)**

# 10/07 - Tong Lecture

ANA CLARA TOSCANO - Dec 10, 2025, 6:15 PM CST

**Title: Kristin Tong Lecture**

**Date:** 10/07

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:**

- Discuss pathways to create systemic impact in healthcare.
- Explore aligning personal skills with solving hard problems.

**Content:**

The conversation centered on navigating a career aimed at solving systemic issues in U.S. healthcare, using the speaker's own journey as a framework.

**Key Themes & Advice:**

1. **Follow the Hard Problems:** The path isn't linear. Focus on developing skills by tackling complex, meaningful challenges (e.g., primary care in rural areas, affordability, patient experience, food insecurity).
2. **The Root Challenge in Healthcare:** The system is "broken" due to **fundamentally misaligned incentives** (e.g., primary care is undervalued). It functions as a fragmented collection of parts, not a unified system designed for patient outcomes. This "brokenness" is an opportunity for entrepreneurs.
3. **Skill Development Strategy:**
    - **Seek Diverse Exposure:** Gain experience across different roles (marketing, sales, operations) and live in different places. The speaker's own path included clinical work (OB/GYN network), startups, and consulting.
    - **Build in Teams:** Progress from demonstrating individual capability to organizing teams and showing how to drive collective impact.
    - **Environment is Key:** "You are defined by the 5 people you spend the most time with." Intentionally surround yourself with **smart, curious, and driven people**.
4. **Personal Foundation:**
    - **Know Your Values:** Identify what matters most to you and protect those values in your career choices.
    - **Prioritize Your Health:** This is non-negotiable, especially in high-stress fields.
    - **Embrace Curiosity:** Let your interests guide your learning and path.

- **Collaboration:** Being in an office with others for interaction is very important for creativity and growth.

**Conclusions/action items: To fix a broken system, you cannot follow a traditional path. You must be strategic in building a unique toolkit, a powerful network, and a resilient personal foundation, all while relentlessly focusing on the core problem you want to solve.**

# 2025/12/05- Outreach Report

ANA CLARA TOSCANO - Dec 10, 2025, 6:21 PM CST

**Title: Outreach Report**

**Date:** 12/05

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Outreach Report

**Content:**

*Wiggle Bots & Lumi Bots*

Organization: University of Wisconsin-Madison Department of Biomedical Engineering

Contact person/s: Steph Vigmond, Giulia Scimonelli, Ana Toscano, Sophia Speece

Contact information: vigmond@wisc.edu, scimonelli@wisc.edu, atoscano2@wisc.edu, sspeece@wisc.edu

## General Description

**Type of activity**

A Wiggle Bot is a silly little robot that moves because it shakes! When you hook up a small motor to a battery and attach a wiggly weight, the whole thing starts to vibrate. The vibrations make the robot dance, spin, and draw fun patterns if you give it marker legs.

A Lumi Bot is a small cup that lights up. Students decorate the cup and then connect a simple light (like an LED) to a battery. When the arms connect, the circuit is completed and the LED lights up. It's like making your own little lantern.

## Program Objectives

**Big idea:** (2 sentences describing the overall theme/topic of the outreach project)

The big idea is that engineering is creative and fun. Kids will explore how electricity works by building their own moving wigglebots and glowing Lumi Bots.

**Learning goals:**

As a result of participating in this program, visitors will be able to:

(3-4 learning goals of outreach project)

1. Use creativity to design and decorate their own Wiggle Bot or Lumi Bot
2. Experiment and try their own ideas to see how changes affect how their Wiggle Bot moves or how their Lumi Bot lights up
3. Understand that a battery can make a motor spin or a light turn on
4. Explain that a Wiggle Bot moves because the motor shakes (vibrates).

5. Explain how the light on a Lumi Bot lights up only when the circuit is connected when the arms are connected.

## Table of Contents



## Time Required

Set-up Program Clean Up

(30 minutes) (2 hours) (15 minutes)

## Background Information

**Definition of terms**

(define any words that the intended audience of the outreach projects may not understand)

DC Motor: A tiny machine that spins when you give it power from a battery. This spinning makes the Wiggle Bot move.

Circuit: A path that electricity travels through. When you connect a battery to a motor using wires, you complete an electrical circuit.

Vibration: Rapid, repeated movement back and forth. When the motor is off-balance, it vibrates and makes the Wiggle Bot “wiggle.”

LED: A light that glows when electricity passes through it.

**Program-specific background**

(define the ideas that the outreach project is based on, i.e. what engineering principles are in play?)

- Circuits create a path for power: When everything is connected in a loop, electricity can flow and turn things on.
- Movement comes from vibration: A motor with an off-balance weight shakes, and that shaking makes the wigglebot move around.
- Design and creativity matter: The way kids build and decorate their wigglebot or lumi bot changes how it looks and moves.

References

Michelle. (2015, July 6). Homemade Wigglebot - A First “Robot.” ResearchParent.com. https://researchparent.com/homemade-wigglebot/

Inspiration for activity: https://www.pinterest.com/pin/949978115133567543/

## Materials

Wiggle Bots (X number of children):

- Disposable cup
- Electrical tape
- 3 markers
- 1 3V button battery
- 1.5-3 V DC Motor
- Super glue
- Tooth picks
- Materials for decorating (googly eyes, pipe cleaners, markers, sticky gems, scissors)
- Blank paper

Lumi Bots (X number of children):

- Small paper cup
- Copper tape
- 1 3V button battery
- Colorful LED
- Needle

- 2 wires with stripped ends
- Materials for decorating (googly eyes, markers, sticky gems)

**REMEMBER: This should be thorough enough to be repeatable**

## Set Up

**Time: 30 minutes**

### Wiggle Bots

**Step 1:** Gather materials

**Step 2:** Tape the markers into the cup as legs

**Step 3:** Attach the battery pack to the DC motor by wrapping the wire around the leads on the motor.

**Step 4:** Tape the battery pack onto the top of the disposable cup slightly off-center

**Step 5:** Tape the DC motor onto the cup

**Step 6:** Attach a weight (like a clothespin or small stick) to the spinning part of the motor so it becomes off-balance and can shake

### Lumi Bots

**Step 1:** Gather all materials.

**Step 2:** Poke a hole on opposite sides of the cup with a needle (will be done by adults)

**Step 3:** Attach the positive side of the battery to the top of the paper cup using copper tape so that one side extends over one side of the cup and over one hole.

**Step 4:** Attach the negative side of the battery to the negative side of the LED using copper tape, and attach the positive side of the LED to the top of the cup, and extend the tape over the side of the cup to cover the opposite hole.

**Step 5:** Poke one wire through the copper tape through the pre-poked hole. Do the same on the other side. Secure the wires in place with copper tape to maintain conductivity.

**Step 6:** Touch the wires together and watch the LED light up

## Program Delivery

**Time: 2 hours**

**Safety:**

(List any potential safety concerns. Allergic materials? Raw materials? Moving components?)

Batteries: Do not mix old and new batteries, and never put batteries in your mouth.

Hot glue: Only adults should handle the hot glue gun.

Scissors: Use scissors carefully when cutting tape or legs.

Stripped wires: Manipulate wires carefully to avoid being poked by the stripped ends - wires will be stripped beforehand and minimal wire will be exposed

LED: Be careful when bending the LED to not poke yourself

Needles: Only adults will handle the needles - holes will be pre-poked into cups

**Procedure and Discussion—(Wiggle Bots):**

**Step 1:** Engage visitors. Have a completed wiggle-bot going on the table, perhaps drawing on a sheet of paper. Ask the visitors if they would like to learn how it works and if they want to make one.

**Step 2:** Start by asking the visitors questions such as “what do we need to make the robot wiggle?” and “what do we need to power the motor?” Can explain the purpose of the battery and taping the wires to the opposite sides.

**Step 3:** Ask visitors what part of their body acts like the motor when they wiggle and dance. Guide them to the muscles. Ask them what part of their body is like the battery sending electric signals to their motor. Guide them to the brain, and describe how the human body activates muscles kind of like the robot: through electrical signals via the nervous system.

**Step 4:** Have the visitor choose a cup and let them decorate it how they choose.

**Step 5:** Have the visitor bring the cup back to the organizers, who will either tape markers to the cup if they want their bot to draw, or hot glue toothpicks to the cup if they just want it to dance. (If supplies allow, the latter option would be better if the visitors want to take the wiggle bot home)

**Step 6:** Finally, tape the motor securely to the top of the cup and the battery to the side of the cup, ensuring the necessary wires are where they need to go to activate the motor.

**Step 7:** Once the visitor is done with their wiggle bot, remove the battery, motor, and markers (if applicable) to re-use for another visitor. Allow them to take home the cup they decorated.

**Procedure and Discussion—(Lumi Bots):**

**Step 1:** Engage visitors. Having an illuminated Lumi Bot can draw people in. When visitors approach, start by finding out their backgrounds, e.g., do they know what a circuit is?

Show the Lumi Bot they can make and take home.

**Step 2:** To explain circuits, explain it as little particles/beads traveling in a circle and how they can only travel in one direction. These particles are called electrons. Like a magnet has a positive and negative end, electricity operates in the same way. In a circuit, these particles move from positive to negative. Also, the particles only move once all parts are connected. In our case, the LED receives power once the circuit is connected, which is done when the Lumi Bot's hands are connected.

**Step 3:** Start by going through a simple diagram of how the circuit works. The copper tape is conductive, meaning it helps these particles move. The battery is the power of the circuit. Have the visitor try to explain back how the circuit works to get the general idea. Explain any points they are confused on again.

**Step 4:** Use the diagram and a pre-made Lumi Bot on the table to show how the circuit works in real life. Explain how there are positive and negative ends on the LED, and positive and negative sides on the battery, and matching these up makes the circuit work (may be more suitable for slightly older children).

**Step 5:** Now that the theory behind the activity is explained, have the visitor choose a cup with pre-poked holes and copper tape on the sides over the hole, and a battery pre-taped on. Have them take note of the side of the battery that is taped down already. Have them choose any color LED they want. Show them how the positive side of the LED is the longer leg, and the negative side is shorter. For those who understand the positive to negative flow, have the visitor try to reason which way the LED will be oriented.

**Step 6:** Once the LED is oriented, have them tape the negative side of the LED to the negative side of the battery, and the positive leg of the LED to the top of the cup with copper tape and explain how the tape is conductive and helps make a circuit. Next, have them pick out 2 wires they want for the "arms".

**Step 7:** Poke the wires through the pre-poked holes and make sure to expose some wire to keep the circuit connected. Once the arms are connected to the cup with copper tape, have the visitors show how the electrons will flow through the circuit. Connect the arms and watch the LED on top light up! (Troubleshoot if needed)

**Step 8:** Have them take the Lumi Bot, draw a face, and decorate in any other way they would like. They can take the Lumi Bot home.

**Tips and Troubleshooting:**

If the LED doesn't light up, ensure all components are correctly connected. If the issue persists, try replacing individual components of the circuit. Connecting the circuit inside the cup can be complicated. Offer assistance if needed.

If the motor doesn't vibrate, first try a new battery, and if that doesn't work, try using a new motor. It is important to note that the batteries should be kept separate from each other because if they are piled on top of each other they can short.

**Common Visitor Questions**

**(List any common questions)**

(Answer)

Q: Why does the LED turn on only when the arms are connected?

A: The electricity only starts flowing when the circuit is connected. By connecting the arms we can close the circuit and electricity can flow and power the LED.

Q: What is the purpose of the battery?

A: The battery provides the pushing force that moves the electrons. Without the battery, the LED would not light up because the electrons would not be flowing through the circuit

Q: How does the motor move?

A: The inside of the vibrational motor is actually spinning, but one side is heavier than the other. This makes the weight shift back and forth, causing it to wiggle or vibrate

### Going Further…

(Describe how the students may further reflect on the outreach project, i.e. activities to do at home, thought-provoking questions)

Mention to the students that the LED lights up on their Lumi Bot similar to how a light is turned on in their house. The general principle is the same, when a switch is flipped, the circuit is connected, allowing electricity to flow. This can be seen in the Lumi bot when the arms are connected.

For the wigglebots, can mention that the muscles that make them move and wiggle and dance are not the only muscles (or body structures) that are stimulated by electrical signals. Can talk about the heart having very important electrical signals, and how we as humans have discovered how to detect and fix irregular heart beats, and even restart a heart that has stopped by using electricity.

For both, we can talk about how the cells in our bodies carry a charge. Cell membranes have a potential difference due to charged ions such as Ca2+, K+, Na+, and Cl-, just like a battery. Ions crossing the cell membrane generate an action potential, and this gets propagated down nerve cells.

## Clean Up

**Time: (10) minutes**

(List the steps required to clean up after the outreach project)

Gather all supplies. Clean up any scraps left from tape or wires.

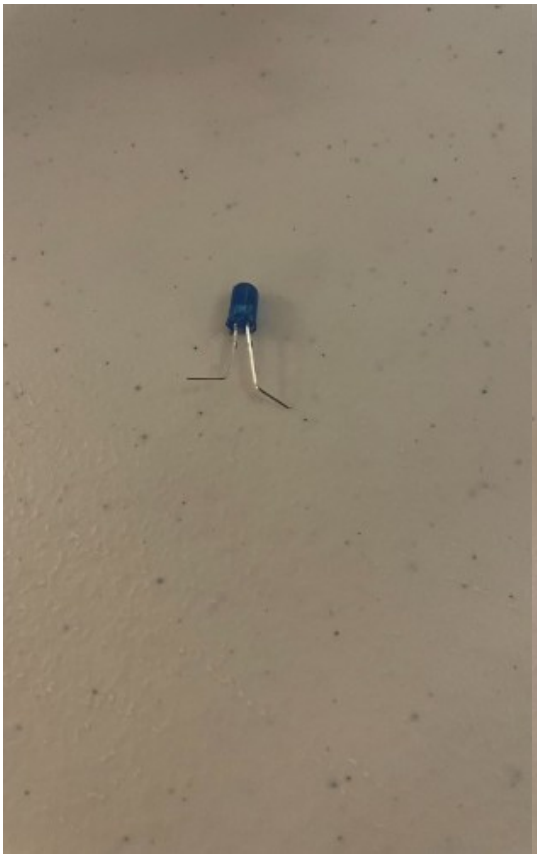
**Lumi Bots - Step-by-Step**

| | |
|---|---|
| 1) Grab a cup. Place the STEM sticker away from you. | 2) Place a strip of copper tape on the positive side of the coin battery. **Make sure it is the POSITIVE side** |

3) Place the taped side of the battery down on the top of the cup. Let the copper tape go over the edge and align with one of the copper strips on the cup.

4) Connect the two strips of copper tape with a third piece

5) Identify the positive (longer) and negative (shorter) side of the LED. Bend the legs about halfway.



6) Attach the **negative** (shorter) side of the LED to the negative side of the battery with copper tape.

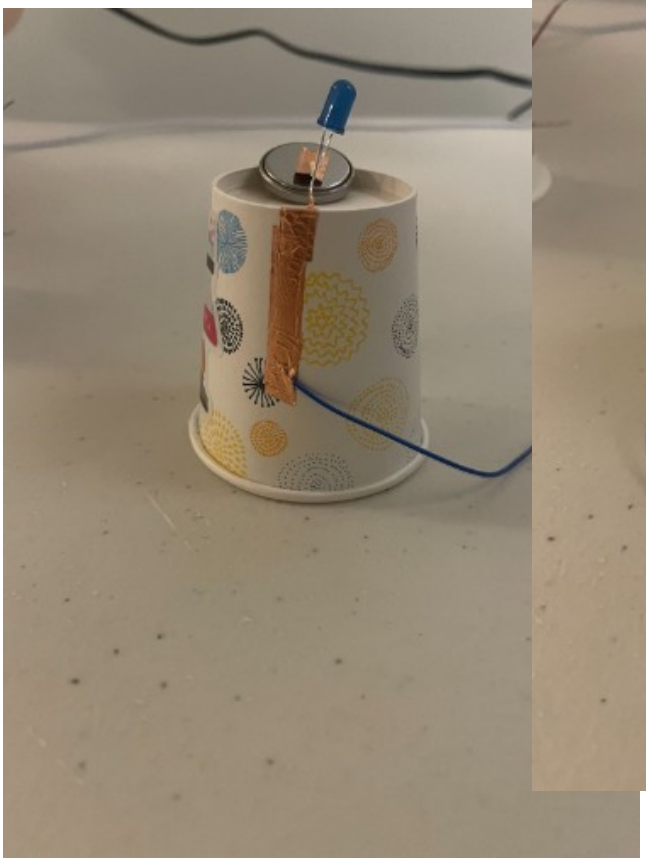
7) Take a longer piece of copper tape and wrap it around the **positive** (longer) leg of the LED and connect it to the other piece of copper tape.

8) Take one wire and identify the part of the wire where it is stripped (no plastic)

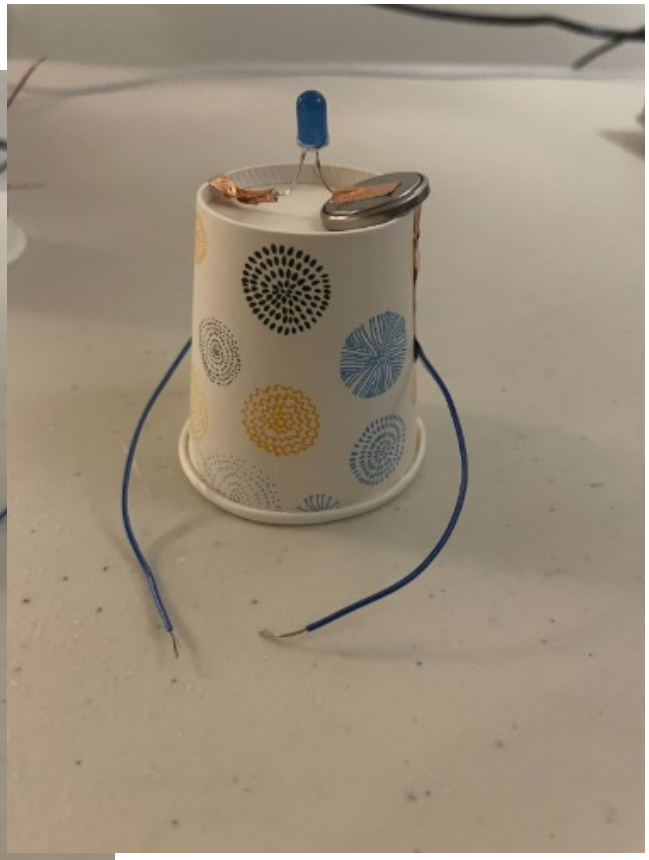
9) Place the wire into the hole, making sure to **leave** part of the exposed wire on the **outside** of the hole

10) On the **inside** of the cup, bend the wire to help secure it in place.

11) Secure the wire in place with copper tape, making sure there is contact between exposed wire and copper tape.

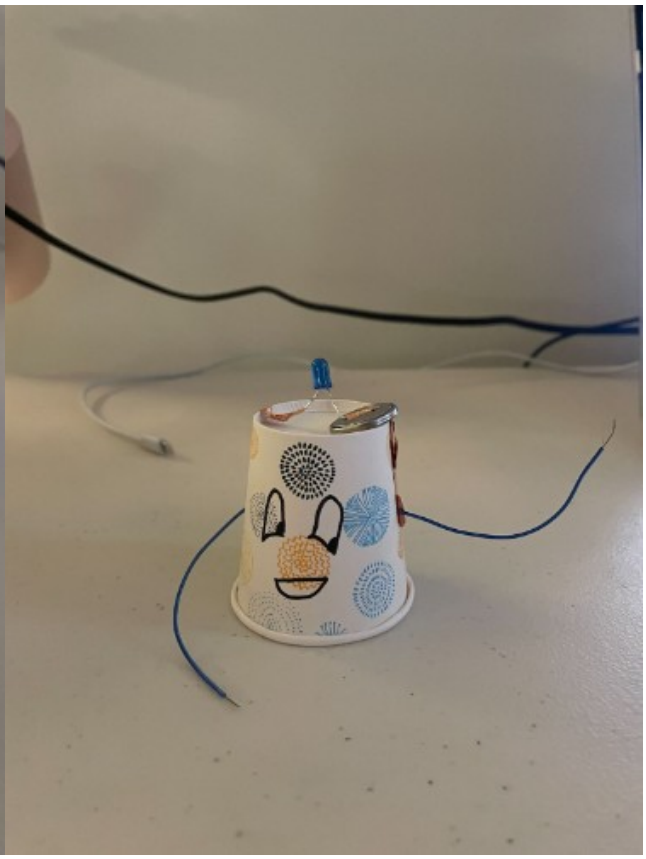


12) Repeat on other side



13) Connect the robot’s hands and watch it light up!

14) Decorate!



# 2025/11/14 - Updated Protocol for Sheer Stress and Velocity

ANA CLARA TOSCANO - Nov 14, 2025, 1:10 PM CST

**Title: Updated Protocol ANSYS Fluent**

**Date:** 11/14

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** ANSYS Fluent: velocity, and strain and stress simulation protocol

**Content:**

Protocol for Analyzing Strain, Stress, and Velocity in ANSYS Fluent

In ANSYS Fluent, velocity is a core output from CFD simulations, while strain and stress are typically derived from fluid-structure interaction (FSI) coupling with a structural solver like ANSYS Mechanical, as Fluent focuses on fluid dynamics. Direct strain/stress calculation in pure fluid simulations is limited to wall shear stress (a fluid property), but full tensor-based stress/strain requires FSI for solid deformation under fluid loads. Below is a step-by-step protocol based on standard ANSYS workflows, integrating simulation setup, solving, and postprocessing. This assumes a two-way FSI scenario (e.g., fluid flow deforming a structure, altering flow).

1. Setup Phase: Model Preparation

- Geometry and Meshing: Use ANSYS SpaceClaim or DesignModeler to create fluid and solid domains (e.g., flow over a flexible plate). Mesh the fluid domain in Fluent Meshing or Ansys Meshing (inflation layers near walls for boundary layer resolution). Mesh the solid in Mechanical for structural accuracy. Ensure interface surfaces match for coupling.
- Material Properties: In Fluent, define fluid properties (density, viscosity). In Mechanical, assign solid properties (Young's modulus, Poisson's ratio) for stress/strain computation.
- FSI Coupling: In ANSYS Workbench, drag Fluent and Mechanical analyses into a System Coupling project. Connect interfaces: Fluid pressure/force to structural loads; structural displacement to fluid mesh motion (using dynamic mesh or remeshing in Fluent).
    - For one-way FSI (simpler, no feedback): Export Fluent pressures to Mechanical for stress/strain only.
    - Enable two-way via System Coupling for iterative bidirectional exchange (fluid affects structure, structure affects fluid velocity field).

Reference: Complete Guide to Fluid-Structure Interaction (FSI) in ANSYS Fluent (cfdland.com)

2. Simulation Phase: Solving for Velocity, Strain, and Stress

- Fluent Setup (Velocity Field):
    - Define boundary conditions: Inlet velocity/pressure, outlet pressure, walls (no-slip for stationary; dynamic for FSI).
    - Enable turbulence model (e.g., k-epsilon) if needed.
    - For FSI, activate dynamic mesh (smoothing/remeshing) or use moving reference frame for structure motion.
    - Solve the transient or steady-state CFD to compute velocity field (u, v, w components).
- Coupling and Structural Solve (Strain and Stress):
    - In System Coupling, set data transfer: Map Fluent's wall pressure/shear to Mechanical loads.
    - Solve Mechanical for displacements, then compute stress tensor (normal/shear: σ_xx, σ_xy, etc.) and strain tensor (ε_xx, γ_xy, etc.) using Hooke's law or nonlinear materials.
    - Principal stresses/strains (invariants: σ1 > σ2 > σ3) and max shear stress/strain are derived automatically.
    - Iterate: Structural deformation updates Fluent mesh, altering velocity field (e.g., via UDF for motion).
    - Convergence: Monitor residuals < 10^-4; use 3 levels of iteration in System Coupling (data, aero, structure).

Key Outputs:

- Velocity: Vector field (magnitude, direction).

- Stress: 3 normal + 3 shear components; von Mises equivalent for yielding.
- Strain: Principal strains (ε1 > ε2 > ε3); max shear strain γ_max.

3. Postprocessing Phase: Visualization and Extraction

- In Fluent (Primarily Velocity):
  - Load results (.cas/.dat files).
  - Create surfaces (e.g., isosurfaces, planes) via Surface > Create (e.g., mid-plane for velocity contours).
  - Graphics: Contours for velocity magnitude; vectors for direction (fixed length via Vector > Symbol > Fixed Length).
  - Plots: XY plots of velocity vs. position; reports for max/min velocity, mass flow.
  - Wall Shear Stress: Custom field function or report > Surface Integrals (for fluid-induced stress on walls).
  - Export: To CFD-Post for advanced viz (e.g., streamlines).
- In Mechanical or CFD-Post (Strain and Stress):
  - Probe results: Equivalent stress/strain contours on deformed geometry.
  - Tensor plots: Normal/shear components; principal directions (eigenvectors).
  - For FSI: Use CFD-Post to overlay velocity vectors on deformed structure, showing interaction (e.g., velocity gradients causing strain).
  - Charts: Stress-strain curves (e.g., via Solution > User Defined Result > Expression for σ vs. ε).
  - Animations: Transient deformation with velocity field evolution.
- Validation: Compare principal stresses with invariants; ensure strain compatibility (e.g., ε = (1/E) * σ for linear elastic).

| Output Type | Tool | Key Visualization | Example Metric |
|---|---|---|---|
| Velocity | Fluent/CFD-Post | Contours, Vectors, Streamlines | Magnitude (m/s), Components (u,v,w) |
| Stress | Mechanical | Contours, Principal Plots | Von Mises (Pa), Max Shear (Pa) |
| Strain | Mechanical | Deformation, Tensor Plots | Principal Strain (%), Max Shear Strain (%) |

**Conclusions/action items:**

Limitations: Pure Fluent lacks full solid stress/strain without coupling; use for fluid-only shear stress via Viscous > Wall Shear Stress.

Reference: Tutorial - Post Processing in Ansys Fluent (innovationspace.ansys.com); How to calculate the shear stress of the fluid in ANSYS Fluent (innovationspace.ansys.com)

# 2025/11/19 - Final CERVIC Protocol for Sheer Stress and Velocity

ANA CLARA TOSCANO - Nov 19, 2025, 7:02 PM CST

**Title: Final CERVIK Protocol ANSYS Fluent**

**Date:** 11/19

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** ANSYS Fluent: velocity, and strain and stress simulation protocol

**Content:**

FLUENT APP LAUNCHER: From the launcher window

# Fluent Simulation Protocol — No Boundary Layers (Updated

**Date:** 11/20/2025
**Author:** Ana Toscano

## Summary

This protocol documents the ANSYS Fluent (Student) workflow for importing an SLDPRT-derived CAD, generating a mesh, running a CFD solution, and producing presentation-ready outputs (velocity, pressure, wall shear stress contours, plots, and animations). **Note:** boundary-layer inflation was attempted but produced conflicting-boundary errors. For this run, **no boundary layers** will be applied. A follow-up simulation will include properly configured boundary layers to improve near-wall accuracy and wall shear stress estimates.

---

## Key choices made for this run

- Geometry: contains **solid, fluid, and vacuum parts**.
- Estimated number of fluid regions: **1** (single continuous cavity used for flow).
- Cap openings: **Yes** (to create closed fluid volume).
- Change all fluid boundaries from wall to internal: **No**.
- Share topology: **No**.
- Multizone meshing: **No**.
- **Boundary layers: Not added for this simulation** due to conflicting-boundary errors. Will be added in next simulation after geometry/zone cleanup.

---

## Workflow (Step-by-step)

This section assumes you are using ANSYS Fluent Student via the Fluent Meshing → Solution mode (no SpaceClaim). Follow the numbered steps exactly.

### 1) Import geometry

1. Fluent Launcher → Meshing Mode (3D, Double Precision).
2. File → Import → CAD → select STEP/IGES/STL (or import converted SLDPRT). Choose **Length Unit** = mm (or your CAD units). Use **CAD Faceting** for tessellation.
3. In the import dialog: answer prompts exactly as used for this run:
    - Geometry consists only of solid regions? **Yes**

- Cap openings? **Yes**
- Change all fluid boundaries from wall to internal? **No**
- Share topology? **No**
- Enable Multizone meshing? **No**

### 2) Surface mesh

1. Workflow → Watertight Geometry → Add Local Sizing (recommended: **Yes**). Use **Face Sizing** for important walls.
2. CFD Surface Mesh Controls: disable "Use Size Field File"; set **Minimum Size** (e.g., 0.5 mm); **Growth Rate** 1.2; **Size Functions** = Curvature (+ Proximity if needed).
3. Generate the surface mesh (Mesh → Generate Surface Mesh). Verify there are no tiny sliver faces or duplicate faces.

### 3) Volume mesh (no boundary layers)

1. Workflow → Watertight Geometry → Generate Volume Mesh.
2. Mesh method: use **Tetrahedral (poly) / Tet**. **Do not** add boundary-layer inflation in this run.
3. Generate the volume mesh. Check mesh quality (skewness, orthogonal quality). If poor, use Mesh → Improve → Swap / Smooth / Optimize.

### 4) Switch to Solution Mode

1. Top bar → Switch to Solution Mode. Fluent will load the mesh.
2. File → Read → Mesh (verify zones and face names). Use Mesh → Tools → Compute Volume Regions if needed.

### 5) Define physics and BCs

1. Models → Viscous → set **k-omega SST** (recommended for shear accuracy). Energy: Off unless thermal simulation needed.
2. Materials → set fluid properties (Air or water, as appropriate).
3. Boundary Conditions → assign zones: Inlet (Velocity Inlet), Outlet (Pressure Outlet), Walls (No-slip). Verify wall zones are correctly identified and **remain as walls** (we did not convert them to internal).

### 6) Solution setup and run

1. Solution Initialization → Hybrid Initialization.
2. Solution Methods → use second-order schemes where available.
3. Run Calculations → set iterations (e.g., 500–1000). Monitor residuals, forces, and mass flow. Aim for residuals < 1e-4 and stable integral quantities.

### 7) Postprocessing (presentation deliverables)

1. Velocity contours: Graphics & Animations → Contours → Velocity Magnitude. Create mid-plane slice if useful.
2. Vectors: Graphics & Animations → Vectors (Fixed length for clear arrows).
3. Wall Shear Stress (WSS): Graphics & Animations → Contours → Wall Shear Stress on wall surface(s). NOTE: without inflation, WSS values are indicative but less accurate — annotate this limitation in your presentation.
4. Line/XY plots: Surface → Line/Rake → XY Plot (e.g., velocity vs position). Export CSV for plotting in Excel/Matlab.
5. Reports: Reports → Surface Integrals → compute area-weighted average and maximum WSS; compute forces/drag on surfaces.
6. Animations: Graphics & Animations → Create Animation → Contour/Streamline options → export frames or MP4 (use export frames + ffmpeg for higher control).

### 8) Export

- Export final mesh and case/data: File → Write → Case & Data (.cas/.dat).
- Export images at high resolution (PNG/TIFF, 300 dpi) for slides.
- Export CSV data for XY plots and tables.

---

## Notes on boundary-layer inflation (for future runs)

- Inflation was attempted but produced a conflicting-boundary error. This likely means inflation tasks were applied to internal or duplicate faces. Before re-adding inflation, perform these checks:
    1. Repair → Merge duplicate faces / Remove small faces.
    2. Compute Volume Regions and ensure wall zones are external wall types.
    3. When adding inflation, select zone names (wall zones) explicitly, not using box selection.
    4. Recommended inflation settings when re-adding: 8–12 layers, growth rate 1.15–1.25, total thickness ~0.5–1.0 mm (adjust to geometry scale). Aim for first-layer height consistent with y+ target (if calculating y+).

---

## Limitations and reporting

- WSS results from this run are **qualitative / indicative** because no inflation layers were present. For publication-quality WSS, rerun with properly configured inflation layers and re-evaluate mesh quality and y+.
- Document the error messages encountered (copy the message console text) and attach the meshing screenshots when seeking further help.

---

## Quick checklist before next run (with inflation)

- Repair geometry (merge faces, cap tiny holes)
- Recompute volume regions
- Remove any conflicting/duplicate mesh tasks
- Add boundary-layer inflation selecting wall zones explicitly
- Re-generate surface & volume mesh
- Check mesh quality

Conclusions: Simulation failed, i think one of the assumptions created an error. Note did not get an error.

# 2025/11/19- Importing SolidWorks Part

ANA CLARA TOSCANO - Nov 19, 2025, 10:30 PM CST

**Title: Importing SolidWorks Part**

**Date:** 11/19

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Protocol for **Importing SolidWorks Part**

**Content:**

- **Open ANSYS's ProductConfig**
  - Go to your ANSYS installation folder.
  - Launch `ProductConfig` (in older versions this may be called Configuration Manager).
  - In the dialog, under *Configure Products & CADs*, enable the **SOLIDWORKS Geometry Interface**.
  - Proceed to complete the setup.
- **Import in Workbench**
  - In ANSYS Workbench, create a new Geometry cell (for example, using DesignModeler or SpaceClaim).
  - Right-click → *Import Geometry* → pick your `.sldprt` (part) or `.sldasm` (assembly) file.
  - If using DesignModeler, you can then "Edit Geometry" → *Generate*. If it loads successfully, your interface is correctly configured.

**Conclusions/action items: Troubleshooting and finding the right files for Configure products was tricky but doable with protocol**

# 2025/11/19 - Circuit Testing Protocol

ANA CLARA TOSCANO - Nov 19, 2025, 8:11 PM CST

**Title: Circuitry Testing Protocols**

**Date:** 19 Nov 2025

**Content by: Dominique and Ana**

**Present: Ana, Dominique and Mahrati**

**Goals:** update the circuit testing protocol for 20 November 2025 testing

Content:

Title: Circuitry Testing Protocols

Date: 19 Nov 2025

Content by: Dominique and Ana

Present: Ana, Dominique and Mahrati

Goals: update the circuit testing protocol for 20 November 2025 testing

Content:

Test 1:

How long (how many turns) it takes for the hole not align anymore (either totally not aligned or like 50%)

Parameters: using the 60% and using the appropriate value accounting for angle

Check question: Need to get the expected pulse width for the micro servo motor

Test 2: Mechanical Torque Measurement (if possible used force sensor)

Purpose: Ensure the servo motor is functional and can rotate the IRE by 60degrees for each cycle

Steps:

1. Operate code as normal.

2. Allow servo motor arm to rotate and measure displacement with a protractor.

3. Repeat for as many cycles as necessary.

Test 3:

before it finishes the cycle, see if the starting point changes

Continuity and consistency - 5 min

# Sheet-based extrusion bioprinting

SOPHIA SPEECE - Sep 19, 2025, 12:42 PM CDT

**Title: Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications**

**Date:** 9/17

**Content by:** Sophia Speece

**Present:** Sophia

**Goals:** Read and take notes on the following document to gain background understanding on the project.

**Content:**

Note: This paper was provided by the client as important information

- Introduction
  - The vascularization problem
    - People need transplants, but there are donor shortages. Therefore many tissue engineering methods are in development, such as bioprinting.
    - Bioprinting: 3D printing pre-determined geometries using viable cells, biomaterials, and biomolecules as printing materials.
    - The problem is that bio-printed tissues are not vascularized. Every cell must be within 200 micrometers of a capillary in order to survive.
    - Bioprinting can produce hollow, cell-seeded channels, however, the challenge remains in getting these channels to the necessary resolution
  - Pursuing clinical bioprinting technologies
    - Bioprinting must create layers as thin as a single cell to accurately replicate microvasculature
    - It should also be able to incorporate multiple materials
      - For example, endothelial cells line the inner walls of vessels, and the basement membrane is comprised of pericytes
    - *this section details current bioprinting methods and why they are insufficient to tackle the problem*
  - Chaotic printing
    - Chaotic printing: "a patent-pending, multi-material extrusion bioprinting strategy that utilizes chaotic advection in a kenics static mixer (KSM) to produce channels within a filament, creating structures with significantly higher resolution and surface area-to-volume ratios than is possible with traditional extrusion bioprinting devices"
      - Can get down to resolutions of 10 micrometers without a teeny nozzle that produces high shear
  - The CEVIC device
    - Continuously Extruded Variable Internal Channeling): "a novel, patent pending invention that uses chaotic printing principles to achieve novel microvascular patterns."
      - Extrudes hydrogel sheets rather than larger filaments
        - This saves time from having to lay down several rows of filament
      - Can maintain adjacent channeling and resolution from KSM mixers

**Conclusions/action items:**

SOPHIA SPEECE - Sep 19, 2025, 12:22 PM CDT


Biofabrication

PAPER

Sheet-based extrusion bioprinting; a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

Ryan Hooper, Caleb Cummings, Anna Beck, Javier Vazquez-Armendariz, Cleo Rodriguez and David Dean

Abstract

As bioprinting advances into clinical relevance with patient-specific tissue and organ constructs, it must be capable of multi-material fabrication at high resolutions to accurately mimic the complex tissue structures found in the body. One of the most fundamental structures to regenerative medicine is microvasculature. Its continuous hierarchical branching vessel networks bridge surgically manipulatable arteries (~1–6 mm) to capillary beds (~4.0 μm). Microvascular perfusion must be established quickly for autologous, allogeneic, or tissue engineered grafts to survive implantation and heal in place. However, traditional syringe-based bioprinting techniques have struggled to produce perfusable constructs with hierarchical branching at the resolution of the arterioles (~100–10 μm) found in microvascular tissues. This study introduces the novel CEVIC bioprinting device (i.e. Continuously Extruded Variable Internal Channeling), a multi-material technology that breaks the current extrusion-based bioprinting paradigm of pushing cell-laden hydrogels through a nozzle as filaments. Instead, in the version explored here, extruding thin, wide cell-laden hydrogel sheets. The CEVIC device adopts the chaotic printing approach to control the width and number of microchannels within the construct as it is extruded (i.e. on-the-fly). Utilizing novel flow valve designs, this strategy can produce continuous gradients varying geometry and materials across the construct and hierarchical branching channels with average widths ranging from 621.5 ± 42.02% μm to 11.67 ± 14.09% μm, respectively, encompassing the resolution range of microvascular vessels. These constructs can also include fugitive/sacrificial ink that vacates to leave demonstrably perfusable channels. In a proof-of-concept experiment, a co-culture of two microvascular cell types, endothelial cells and pericytes, maintained over 90% viability throughout 1 week in microchannels within CEVIC-produced gelatin methacryloyl-sodium alginate hydrogel constructs. These results justify further exploration of generating CEVIC-bioprinted microvasculature, such as pre-culturing and implantation studies.

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**bf_16_2_025032.pdf (2.56 MB)**

# CDC Sterilization Recommendations

SOPHIA SPEECE - Sep 19, 2025, 12:21 PM CDT

**Title: Steam Sterilization - Guideline for Disinfection and Sterilization in Healthcare Facilities**

**Date:** 9/19

**Content by:** Sophia Speece

**Present:** Sophie

**Goals:** Determine temperature, pressure, and humidity requirements that the shutoff valve will need to endure

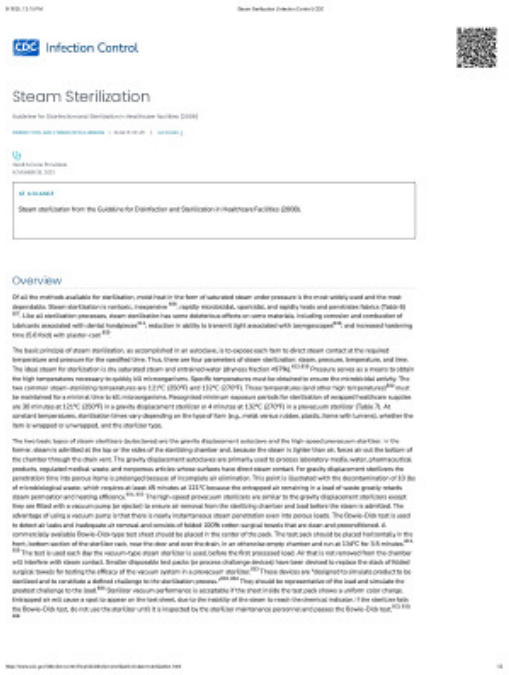
**Content:**

- There are two common steam-sterilization temperatures
  - 121 Celsius
    - Minimum time of 30 minutes for wrapped items
  - 132 Celsius
    - Minimum of 4 minutes
- Sterilization times also differ depending on materials

**Conclusions/action items:**

More information is needed to determine the exact type of sterilization needed and what is used in Dr. Dean's lab

SOPHIA SPEECE - Sep 19, 2025, 12:21 PM CDT


Infection Control

Steam Sterilization

Overview

Download

**Steam_Sterilization___Infection_Control___CDC.pdf (217 kB)**

# Autoclave Table

SOPHIA SPEECE - Sep 19, 2025, 12:14 PM CDT

**Title: Autoclave Time Temperature Pressure Chart**

**Date:** 9/19

**Content by:** Sophia Speece

**Present:** Sophie

**Goals:** Determine maximum temperature, pressure, and humidity that the shutoff valve will need to withstand

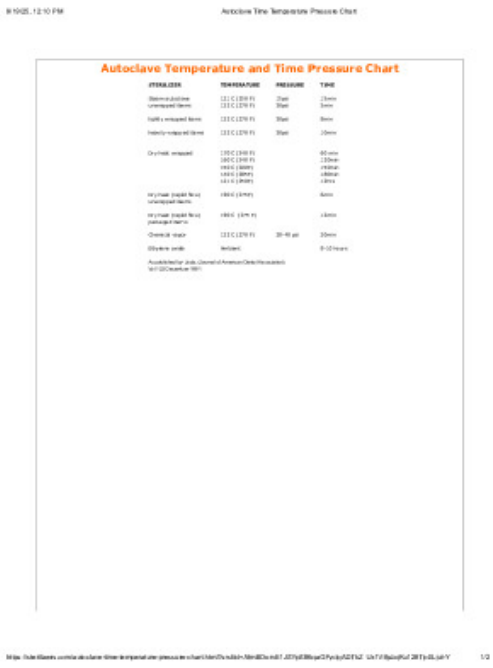
**Content:**

See table attached below

**Conclusions/action items:**

Include this information in the PDS to list the temperature, pressure, and humidity withstand requirements for the shutoff valve

SOPHIA SPEECE - Sep 19, 2025, 12:11 PM CDT

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**Autoclave_Time_Temperature_Pressure_Chart.pdf (262 kB)**

# Fluid Dynamics 101

SOPHIA SPEECE - Sep 24, 2025, 2:30 PM CDT

**Title: Fluid Dynamics 101: Basics to Understanding How Fluids Flow**

**Date:** 9.24.25

**Content by:** Sophia Speece

**Present:** Sophie

**Goals:** Client said that having an understanding of fluid dynamics, and how they might work in the kenic static mixers and CENIC mixer could help with the project. It is also good background if we try to model it with a computer simulation.

**Content:**

- What is fluid dynamics?
  - Def: a branch of engineering/physics/math that looks at the behavior of fluids (both liquid and gas) in motion. including the forces and interactions that influence how fluids flor and change.
- Fluids and their Properties
  - Fluid: a substance that can flow and take the shape of the container that it is in
  - Liquids versus gasses
    - Liquid molecules are more tightly packed. They take the shape of their container, but their volume doesn't really change
    - Gas molecules are widely spaced, and does not have a definite shape, and their volume can change with temperature and pressure
  - Key Properties include:
    - Kinematic properties
      - Velocity: speed and direction of the fluid/its particles with respect to time
      - Acceleration: rate of change of velocity
    - Thermodynamic properties
      - Temperature: average kinetic energy of the fluid molecules
      - Pressure: Force exerted by the fluid per unit area on its surroundings
      - Density: Mass of the fluid per unit volume
    - Physical Properties
      - Viscosity: the internal resistance to flow
      - Surface Tension: the elastic tendency of fluid surfaces
      - Buoyancy: Ability of fluids to exert an upward force on objects
- Types of Fluid Flow
  - Flow: The movement of fluid particles in a certain environment
  - Laminar (streamline)
    - Liquid flows in smooth, parallel layers, with minimal mixing between the layers. Usually low velocity, high viscosity flow
  - Turbulent
    - Chaotic and seemingly random. Fluid has eddies, swirls, and fluctuations in velocity and pressure. Usually high velocity and low viscosity
  - Other classifications
    - Steady flow: Fluid properties (velocity, pressure, etc) remain constant at any given point in time
    - Unsteady flow: fluid properties vary with time
    - Compressible flow: fluid density varies significantly with pressure (usually gasses)
    - Incompressible flow: fluid density is constant (usually liquids)
    - Viscous flow: fluid molecules transfer momentum between layers due to their viscous properties (layers nearer to the surface move slower than the layers further away)
    - Inviscid flow: an idealized model that assumes the fluid has 0 viscosity and viscous forces are negligible (ideal flow, uniform velocity throughout)
- "Beyond the Basics"
  - Bernoulli's Principle

        - As the speed of a fluid increases, the pressure decreases
        - Explains lift, curveballs, etc.
    - Reynold's Number
        - (Re), dimensionless, used to predict if a type of flow is laminar or turbulent
        - A low number indicates laminar flow, and a high number indicates turbulent flow
        - Therefore, useful for calculating appropriate size and diameter
        - Formula: Re = (rho*V*L)/mu
            - rho is the density of the fluid (kg/m^3)
            - V is the characteristic velocity of the flow (m/s)
            - L is the characteristic length scale of the flow (ex. diameter) (m)
            - mu is the dynamic viscosity of the fluid (Pascals)
    - Pascal's Law
        - States that pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid and to the walls of the containing vessel
        - Basis for hydraulic systems, using fluids to transmit force and power
    - Continuity Equation
        - For any incompressible fluid, the mass flow rate must remain constant from one cross-section of a pipe to another. As diameter narrows, the fluid must speed up to maintain the same flow rate.
    - Computational Fluid Dynamics (CFD)
        - Use computers to simulate and analyze fluid flow.

**Conclusions/action items:**

If needed, can use this information to quantify fluid flow of the hydrogel through the printers and mixers, making sure that our design does not disrupt the gel or add bubbles or turbulence.

---

SOPHIA SPEECE - Sep 24, 2025, 2:12 PM CDT


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**Fluid_Dynamics_101__Basics_to_Understanding_How_Fluids_Flow_-_Electricsolenoidvalves.com.pdf (506 kB)**

# Organ Donation Statistics

SOPHIA SPEECE - Dec 15, 2025, 9:05 PM CST

**Title: Organ Donation Statistics**

**Date:** Entered 12/15/2025, researched at start of the semester

**Content by:** Sophie Speece

**Present:** N/A

**Goals:** Learn about the impact of organ donation and the disparities between supply and demand

**Content:**

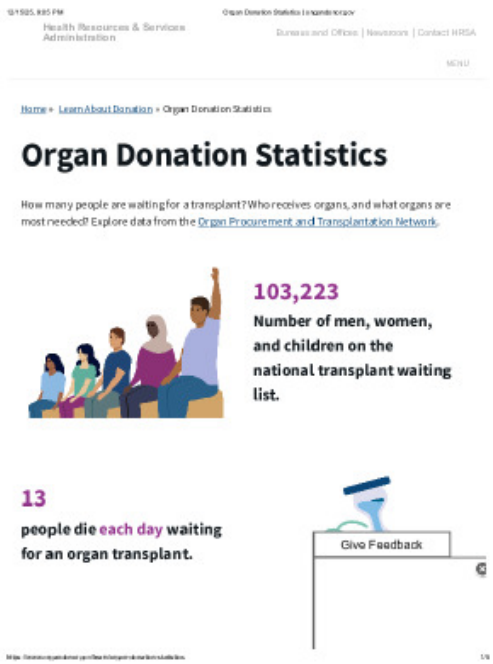
- As of today, 103,223 people are on the transplant waiting list in the United States
- 13 people dies each day waiting for an organ transplant
- Every 8 minutes, another person is added to the transplant waiting list
- The most common transplanted organ by far is the kidney

[1] "Organ Donation Statistics | organdonor.gov." Accessed: Sep. 18, 2025. [Online]. Available: https://www.organdonor.gov/learn/organ-donation-statistics

**Conclusions/action items:**

Tissue engineering can help to close organ donation gaps

SOPHIA SPEECE - Dec 15, 2025, 9:06 PM CST

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**Organ_Donation_Statistics___organdonor.gov.pdf (918 kB)**

# Integrated Rotary Element Design Idea

SOPHIA SPEECE - Dec 15, 2025, 7:43 PM CST

**Title:** Design Brainstorming Idea: Integrated Rotary Element

**Date:** Entered 12/15/2025, conceived in September

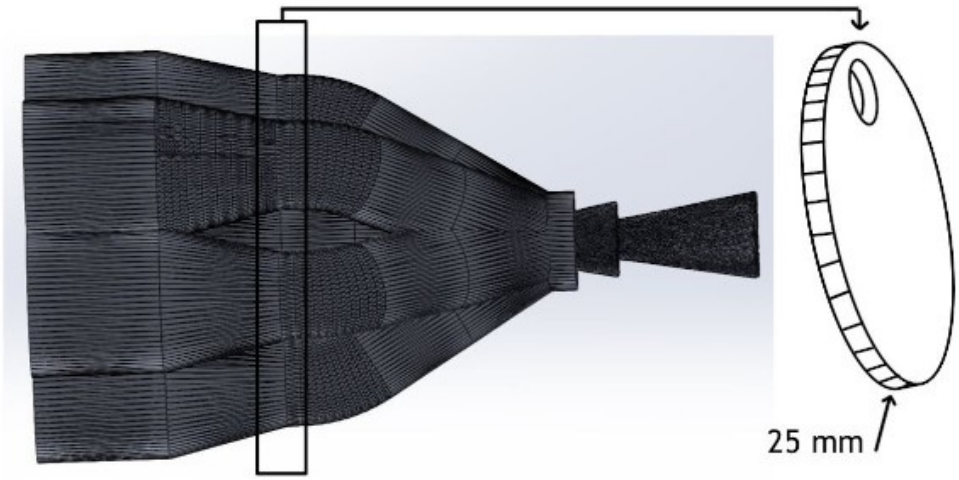
**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Brainstorm one or more ideas for the preliminary presentation and therefore semester project

**Content:**

Cut the CEVIC device in half, then place the disk in between the two parts. The disk on the inside will have one hole so it will only let one channel of hydrogel output at one time. The side will have ridges/teeth so it can interface with a servo motor. Required later development of some kind of connection mechanism.




**Conclusions/action items:**

Need to brainstorm a form of connecting mechanism, then model in SolidWorks, then print to test

# Water Jet Training

SOPHIA SPEECE - Dec 15, 2025, 7:36 PM CST

**Title: Water Jet Training - Sophia Speece**

**Date:** Entered 12/15/2025

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Complete water jet training

**Content:**

See below for proof of Water Jet Training quiz completion. Water Jet Project was done at the UW Makerspace. A brass sheet was cut into a couple of designs to make suncatchers as a personal project.

**Conclusions/action items:**

This training can be used to aid fabrication in the future as waterjet is capable of cutting many materials with extremely fine details.

SOPHIA SPEECE - Dec 15, 2025, 7:36 PM CST


Download

**BME_400_Training.JPG (144 kB)**

# 11/7 Tong Lecture

SOPHIA SPEECE - Nov 07, 2025, 12:54 PM CST

**Title: Tong Distinguished Entrepreneurship Lecture - Kristin Myers**

**Date:** 11/7

**Content by:** Sophia Speece

**Present:** Team (each may have their own page)

**Goals:** Learn about why healthcare needs more engineers

**Content:**

Kristin Myers, graduated 2002 in a class of 30 BME, 2007 MBA from Harvard

- Chapter 1
  - Early career and schooling, technical foundations
- Chapter 2
  - Post business school
- Chapter 3 Build and Transform
  - Ended and is currently COO at Blue Cross Blue Shield
    - How to make healthcare affordable and accessible and improve patient experience
    - Quadruple aim
    - Also provider experience
- "You don't need to know your final destination - just follow hard problems and build skills that allow you to make an impact
- 18% of GDP is for healthcare, spend 2x compared to other high income countries per person, many people skip on care due to costs
  - Our healthcare system is vary broken, how do we even approach fixing it?
- Healthcare needs better systems. And systems are what engineers build best.
  - Integration is an engineering problem
- Steps
  - 1 Work Hard and Build Range - take on the hardest projects, classes, and experiences you can find. Effort and range are your foundation
  - 2 Seek Diverse Exposure - explore different sectors, teams and geographies. Gain perspective and learn how systems connect, not just how parts work
  - 3 Choose Your People Wisely - Surround yourself with curious, driven, high-integrity people. They will shape who you become
  - 4 Know Your Values and Protect Them - Define what matter most (family/friends, health, career/impact, values) and make decisions that align
  - 5 Embrace Challenge and Keep Growing - Run towards hard problems, growth lives on the edge of discomfort, where big impact starts
- Questions time
  - How to avoid burnout?
    - People have times of day they are built for, capitalize on when you are active. Block calendar for your own responsibilities, put stuff that requires less focus at a lower energy time. Don't be afraid to say no

**Conclusions/action items:**

This woman is very cool

# 2025/09/08 - Sheet-based extrusion bioprinting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 09, 2025, 10:31 PM CDT

**Title:** Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

**Date:** 8 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** gain an overview of the project

**Search term:** Article from Microvascular channel bioprinter shutoff valve page

**Citation:**

R. Hooper, C. Cummings, A. Beck, J. Vazquez-Armendariz, C. Rodriguez, and D. Dean, “Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications,” Biofabrication, vol. 16, no. 2, p. 025032, Mar. 2024, doi: https://doi.org/10.1088/1758-5090/ad30c8.

**Link:** https://pmc.ncbi.nlm.nih.gov/articles/PMC10938191/

**Content:**

- Bioprinting must be capable of multi-material fabrication at high resolutions to accurately mimick the complex tissue structures found in the body
- Range from 1-6 mm to about 10 um
- traditional syringe-based bioprinting techniques have struggled to produce perfusable constructs with hierarchical branching at the resolution of the arterioles (∼100-10 µm) found in microvascular tissues
- novel CEVIC bioprinting device (i.e. Continuously Extruded Variable Internal Channeling)
    - extruding thin, wide cell-laden hydrogel sheets
    - adapts the chaotic printing approach to control the width and number of microchannels within the construct as it is extruded - on the fly
    - Can produce continuous gradients of varying geometry and materials; hierarchical branching; average widths ranging in micrometers --> range for microvascular vessels
    - Constructs can include fugitive/sacrificial ink that is later removed and leaves behind perfusable channels
    - In proof of concept: 90% viability through 1 week
    - Results justify **further exploration of generating CEVIC-bioprinted microvasculature, such as pre-culturing and implantation studies**

- bioprinting - 3D printing pre-determined geometries using viable cells, biomaterials, and biomolecules as printing materials; could generate precisely customizable alternatives to the millions of naturally derived tissue grafts implanted each year
- for bioprinting to reach clinic, must include sufficient and sustained vascularization upon implantation
    - In almost all tissue, cells must be **within 200 um of a capillary** to allow sufficient delivery and waste removal for long-term survival
- Autologous free-flap grafting is commonly combined with bone or other grafted tissue during reconstructive surgical procedures

    - autologous tissue can be sectioned and transferred to a new bodily region while retaining functional vasculature, either within the primary tissue or quickly provided by highly microvascular secondary tissue (e.g. muscle or fat)
    - Allows for immediate blood perfusion upon implantation through microsurgical anastomosis with adjacent blood vessels. However, autologous free flap grafting inherently leads to considerable **comorbidity and often pain at the donor site**
- To provide or initiate vascularization
    - traditionally involve growth factor delivery, cell co-culture, and mechanical stimulation to induce spontaneous capillary bed development
- **missing from the equation** is microvasculature's natural function to hierarchically branch from small-diameter vessel-scale (~1–6 mm) to capillary-scale (~10 µm), reducing blood pressure with each branch division and consistently distributing blood supply throughout capillaries less than 200 µm apart
- vascularization TE has shifted to creating hollow, hierarchical branched networks
    - In addition to bioprinting, other methods include electrospinning, casting, and molding
        - Have potential, but involve dense impenetrable materials
    - Laser-assisted direct writing can help create microchannels, but the laser exposure can impact cell viability and structural integrity
    - Bioprinting can produce hollow, cell-seeded hydrogel channels without requiring laser exposure, but to this point have struggled to successfully mimick the entire resolution range of natural microvascular networks
- the **inability to fabricate an artificial microvascular graft with bioprinting** is a technology gap that, if a useful technology emerged, would be a paradigmatic shift in the field of biofabrication

1.2 Pursuing clinical bioprinting strategies

- Bioprinting will likely need to create layers as thin as a single cell
- Extrusion bioprinting (i.e. driving cell-laden liquid hydrogel through a nozzle to be solidified upon deposition)
    - relatively low cost; could provide scalable tissue and organ printing
- cell-laden hydrogel filaments resulting from traditional extrusion bioprinting have the lowest resolution of all bioprinting modalities (~100 µm)
- Light-assisted bioprinting - inducing hydrogel crosslinking via laser or projected image
    - higher resolution (<10 um) but often requires significant UV light exposure - risk of DNA damage and cancer
    - some use visible light, but requires stronger light sources to provide the same print times and curing quality as UV-based methods
- bioprinting must achieve high resolution, incorporate multiple materials and cell types to replicate the highly structured spatial patterning of different cell types found in native, functional tissues
- Bioprinting constructs containing both ECs and PCs, while still a simplification, can mimic the multi-faceted interactions between these cell types in natural microvascular tissues
- single-nozzle and multi-nozzle devices are being developed
    - multi-nozzle devices - avoid material cross-contamination
    - single-nozzle - allows for one to switch material without stopping the extrusion process; impacts structural integrity and adds additional nozzle alignment and deposition challenges for the device
    - There are also multi-material bioprinting handheld devices that allow for efficient, in situ deposition of fragile tissue constructs directly onto wound sites

1.3 Chaotic Printing

- multi-material extrusion bioprinting strategy that utilizes chaotic advection in a kenics static mixer (KSM) to produce channels within a filament, creating structures with **significantly higher resolution** and **surface area-to-volume ratios** than is possible with traditional extrusion bioprinting devices

- mixing 2 ink inputs into alternating adjacent channels within a filament
- Produce channels under 10 um width without requiring a smaller nozzle than traditional extrusion - avoid clogging and compromised cell viability from increased shear stresses
- higher resolution than UV printing, and no concerns about UV damage
- viable strategy for inducing cell alignment, providing vacant channels for pre-vascularization and rapid cell expansion in high surface-area-to-volume bioreactor systems

1.4 The CEVIC device

- Continuously Extruded Variable Internal Channeling - uses chaotic printing principles to achieve novel microvascular patterns
- **extrudes hydrogel sheets** instead of filaments while maintaining the alternating adjacent channeling structure unique to chaotic printing
- The channels have potential for both cell-seeded microvascular structures or for fugitive inks that set up vacated spaces for nutrient inflow, waste product removal, or subsequent cell seeding
- allows a complete micropatterned construct covering a relatively large area (e.g. at least 25–300 mm2) to be produced in one extrusion, rather than requiring many passes
- can **switch between materials** and kenics mixers mid-extrusion to create variations in bioink type. Also switch channel number and thickness throughout a continuous sheet or filament extruded from a single printhead
- can help with cell alignment; allow perfusion of blood and nutrients
- Allows device to produce hierarchical branching of internal channels with widths going from artery to capillary scale
- Both handheld and fully automated stage of bioprinting
- CEVIC device is the first example of sheet-based extrusion bioprinting for applications outside of in situ bioprinting for wound repair
- first time chaotic printing has been translated to sheet-based extrusion bioprinting, rather than filament deposition, while being the first attempt at modulating channel number and width mid-extrusion throughout a chaotically printed construct for the purposes of replicating the hierarchical branching pattern of native microvasculature with accurate dimensions

2 - materials & methods

2.1 - KSM printheads, static valve, and perfusion chamber creation

- the three mixing elements contained in the original printhead that divide two inputs into 8 layers were duplicated and transformed to construct six new KSM designs with four to nine mixing elements (for outputting 16, 32, 64, 128, 256, and 512 channels, respectively, within the resulting hydrogel sheet)

2.3 - device operation

- hydrogel sheet constructs produced can be combined with woven thermoplastic polymer fiber scaffolds produced by melt electrowriting (MEW) to combine properties of both materials
- allows hydrogel to crosslink around the MEW scaffold - fusing

3 - results and discussion

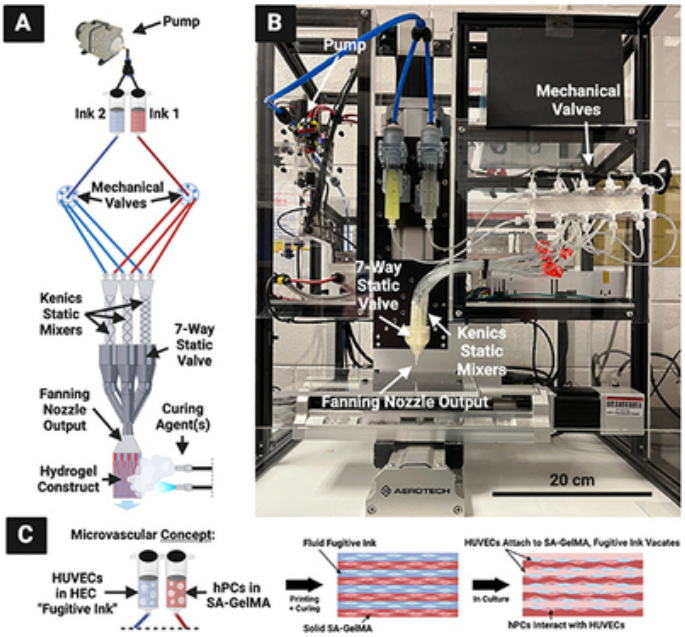
- measured channel widths were relatively close to their ‘theoretical’ widths
- smallest channel width was 10 um
- mid-extrusion pattern switching was demonstrated by transitioning from 8, to 16, then 32 channels within a continuous hydrogel sheet
- sheets tended to be thickest in the center - sheets with more uniform thickness could be produced with more rapid crosslinking or by using a printing surface with higher affinity

- when using fugitive method, not every channel was perfusable, likely due to channel sinking, inexact needle placement, and variable flow rate
- uncured hydrogel was drawn into space within the MEW pores via capillary action between the hydrogel and PCL fibers
- All inks demonstrated shear-thinning behavior, an important ink characteristic for extrusion-based bioprinting to allow flow through the printhead with minimum shear stress on cells

**Conclusion/Action Items:**

- What currently seems to be missing is being able to go from/between mm diameter to um diameter, and back; also ensuring 200 um apart
- bioprinting must achieve high resolution, incorporate multiple materials and cell types to replicate the highly structured spatial patterning of different cell types found in native, functional tissues
- Sections on methods is useful, but not focus of overview
- This article was very interesting and provided some insight into the project. I am still trying to clarify what the focus of our project is.
- Will continue to do research into sheet-based extrusion bioprinting and how it relates to our project

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 09, 2025, 10:11 PM CDT




Download

**bfad30c8f4_lr.jpg (304 kB)** Taken from article: CEVIC device schematic, portraying electric rotary valves for automated input selection. Mechanical valves control which kenics static mixer receives the two ink inputs. The chosen mixer creates a certain number of alternating channels of the two inks within the volume that exits the nozzle output to form a sheet, which is then solidified via curing agent(s). Because varying the number of kenics mixer elements varies the channel number and width, controlling the mechanical valves therefore controls channel number and width in the resulting sheet construct mid-extrusion. (B) Current device iteration, with non-electric/manual mechanical valves for manual input selection. (C) CEVIC microvascular tissue fabrication concept that is first explored in this study with an endothelial cell (HUVEC) and pericyte (hPC) proof-of-concept experiment.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 08, 2025, 11:21 PM CDT

Biofabrication

PAPER

Sheet-based extrusion bioprinting: a new multi-material paradigm providing mid-extrusion micropatterning control for microvascular applications

Ryan Hooper, Caleb Cummings, Anna Beck, Javier Vazquez-Armendariz, Cleo Rodriguez and David Dean

Abstract

As bioprinting advances into clinical relevance with patient-specific tissue and organ constructs, it must be capable of multi-material fabrication at high resolutions to accurately mimic the complex tissue structures found in the body. One of the most fundamental structures to regenerative medicine is microvasculature. Its continuous hierarchical branching vessel networks bridge surgically manipulatable arteries (~1–6 mm) to capillary beds (~4.0 μm). Microvascular perfusion must be established quickly for autologous, allogeneic, or tissue engineered grafts to survive implantation and heal in place. However, traditional syringe-based bioprinting techniques have struggled to produce perfusable constructs with hierarchical branching at the resolutions of the arterioles (~100-10 μm) found in microvascular tissues. This study introduces the novel CEVIC bioprinting device (i.e. Continuously Extruded Variable Internal Channeling), a multi-material technology that breaks the current extrusion-based bioprinting paradigm of packing cell-laden hydrogels through a nozzle as filaments. Instead, in the version explored here, extruding thin, wide cell-laden hydrogel sheets. The CEVIC device adopts the chaotic printing approach to control the width and number of microchannels within the construct as it is extruded (i.e. on-the-fly). Utilizing novel flow valve designs, this strategy can produce constructs containing gradients varying geometry and materials across the construct and hierarchical branching channels with average widths ranging from 621.5 ± 42.02% μm to 11.67 ± 14.09% μm, respectively, encompassing the resolution range of microvascular vessels. These constructs can also include fugitive/sacrificial ink that vacates to leave demonstrably perfusable channels. In a proof-of-concept experiment, a co-culture of two microvascular cell types, endothelial cells and pericytes, remained over 90% viability throughout 1 week in microchannels within CEVIC-produced gelatin methacryloyl-sodium alginate hydrogel constructs. These results justify further exploration of generating CEVIC-bioprinted microvasculature, such as pre-culturing and implantation studies.

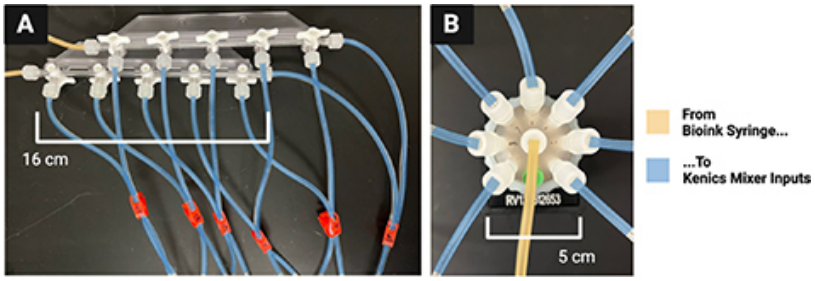
Supplementary material for this article is available online

Keywords: sheet-based 3D bioprinting, multi-material, microvasculature, perfusion, chaotic printing, multi-directional printing

Download

**sheet-based_extrusion.pdf (2.56 MB)**

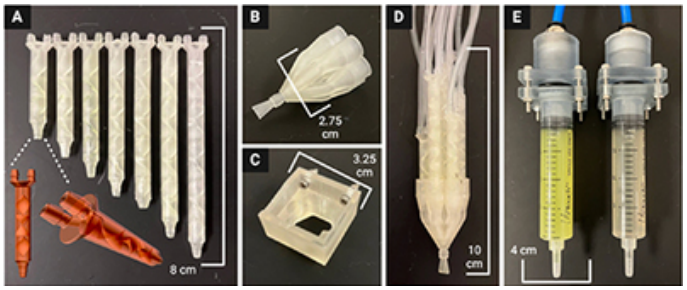
STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 8:01 PM CDT




Download

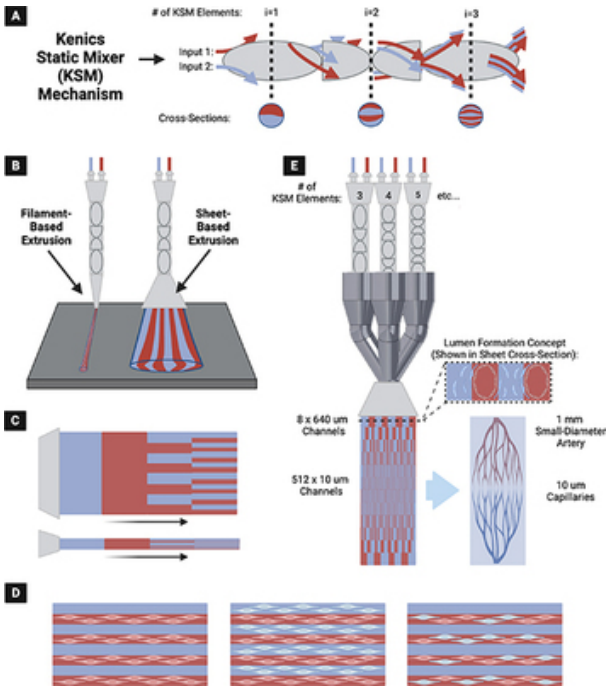
**bfad30c8f3_lr.jpg (92.3 kB)** Two options for mechanical valves to select channel number and width. (A) Manual option, valves are turned by hand to direct two hydrogel inks into a desired KSM to produce the intended number and width of channels in the outputted construct. (B) Automatic alternative using an electric rotary valve. Valve rotates on a stepper motor to direct a hydrogel ink into the desired kenics mixer.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 8:01 PM CDT




Download

**bfad30c8f2_lr.jpg (113 kB)** All 3D printed device components (A) Kenics static mixers (KSMs) with 3-9 mixing elements to produce 8, 16, 32, 64, 128, 256, and 512 channels, respectively. Frontal and isometric views of a KSM *.STL file show the internal mixing elements. A 7-input static valve (B) is either controlled by hand or fixed to a 3D printer (C). (D) KSMs are fit into the 7-input static valve to direct the selected flow pattern through a fanning nozzle outlet, producing a hydrogel sheet. (E) Components to maintain air-tight seal between air pump and syringes containing hydrogel inks.




Download

**bfad30c8f1_lr.jpg (225 kB)** (A) The kenics static mixer (KSM) mechanism employed in chaotic printing, utilizing chaotic advection to mix two or more (shown as two) fluid inputs into alternating striations. Each KSM 'element' (i.e. helicoidal blade that divides and rotates the incoming fluid) included in sequence doubles the number of striations produced. (B) (Left) Original chaotic printing concept for extrusion of filaments containing striations (i.e. alternating internal channels) of two or more hydrogels, vs. (Right) newly introduced concept of fanning the output into a wide sheet while maintaining the alternating internal channel structure—producing a workable micropatterned construct in one extrusion. (C) CEVIC (Continuously Extruded Variable Internal Channeling) device can provide any combination of bioink/channel switching mid-extrusion through a single printhead. (D) Microchannels can house one or more cell types in multiple combinations to promote cell alignment, heterocellular interactions, and/or perfusion, depending on the desired application. (E) The CEVIC device printhead, combining multiple flow pathways through varying numbers of KSM elements in sequence, to produce hydrogel sheets with continuous hierarchical branching channels from artery to capillary-scale (left), a design concept currently being explored as a potential template for culturing microvascular tissue constructs (right).

# 2025/09/14 - Types of IV Clamps

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 9:04 PM CDT

**Date:** 14 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** learn how IV clamps work and learn about different types of IV clamps

**Search term:** how IV clamps work to stop flow

**Citation:** “IV clamp and flow regulator - KMED,” Nov. 25, 2020. https://www.kmedhealth.com/clamp-and-flow-regulator-of-diposable-iv-sets/

**Link:** https://www.kmedhealth.com/clamp-and-flow-regulator-of-diposable-iv-sets/

**Content:**

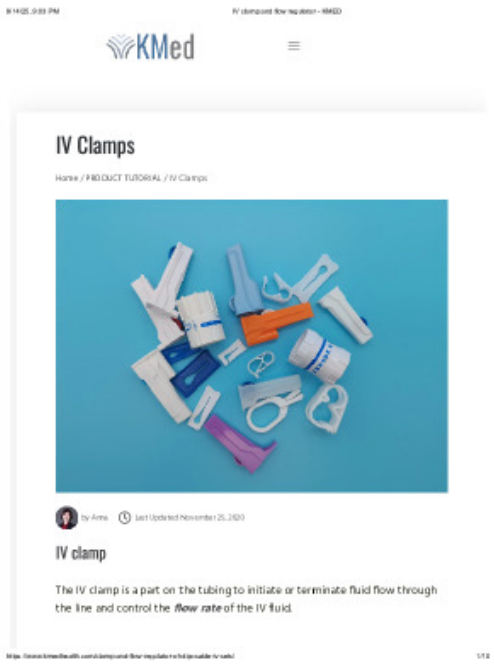
- IV clamps can help start or stop fluid flow through a line, and helps control flow rate
- Different types of IV clamps
  - pinch clamp, slide clamp, roller clamp
- Pinch clamp
  - can be used with flexible tubes that have low-pressure application
  - material: Polypropylene and Polyoxymethylene (POM)
  - resistant and rigid plastic, no sharp edges
  - able to operate with 1 hand; autoclavable
- Slide clamp
  - Cannot make adjustments to flow rate
  - disadvantage: can cause crimping or crease in tubing - hazard
  - material: high-density polyethylene, ABS (Acrylonitrile Butadiene Styrene), and polypropylene
  - heat resistant & compatible with all sterilization process
  - Enables on/off flow of fluid
  - can be operated with 1 hand
- Roller clamp
  - can control the rate of flow
  - closes in increments, so rate of flow can be easily controlled
  - Should be closed before attaching IV bag so no air gets in tubing
  - designed to keep infusion rate constant between adjustments by holding the tube in place
  - placement of roller clamp should be in upper third to prevent accidental changes to settings
  - material: Polyethylene and ABS (Acrylonitrile Butadiene Styrene)
  - Flow regulators protect tube crimping, cold creep, and drifting

**Conclusion/Action Items:**

- While this is a company looking to sell different IV clamps, the distinction between the types is useful
- Consider testing a pinch clamp for this application to stop dripping - will revisit when have a clearer picture of goal

- Continue researching potential clamps or other methods of stopping dripping

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 9:04 PM CDT

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**IV_clamp_and_flow_regulator_-_KMED.pdf (5.4 MB)**

# 2025/09/14 - Automatic pinch valves

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 9:19 PM CDT

**Date:** 14 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Learn about automated options to pinch tubing to stop flow

**Search term:** Automated pinch valve

**Citation:** “Products - Pinch Valves | Emerson,” Emerson.com, 2025. https://www.emerson.com/en-us/catalog/pinch-valves.

**Link:** http://emerson.com/en-us/catalog/pinch-valves

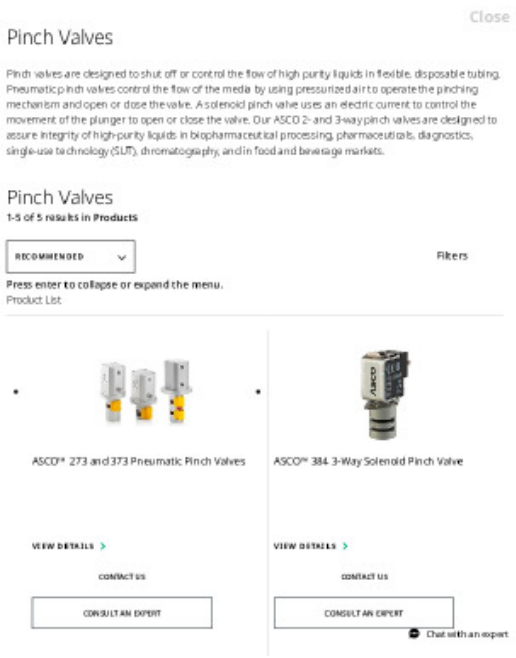
**Content:**

- Can shutoff the flow of high purity liquids in flexible, disposable tubing - clear resin, if thin enough, is flexible so may have similar properties
- Pneumatic pinch valves - use pressurized air to operate pinching mechanism
- Solenoid pinch valve - uses electric current to control movement of plunger to open or close tubing

**Conclusion/Action Items:**

- One option for the project may be to program something to close a valve on the same tubing that just stopped printing to stop the dripping
- Will look into other automated/programmable options and compare - this is also a page selling their product, but not too much bias because they are saying how it functions

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 14, 2025, 9:19 PM CDT



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**Products_-_Pinch_Valves___Emerson.pdf (87.4 kB)**

# 2025/09/17 - Chaotic bio(printing) in the context of drug delivery systems

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 18, 2025, 7:20 PM CDT

**Date:** 17 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Learn about chaotic bioprinting & other applications of it

**Search term:** chaotic bioprinting hydrogel

**Citation:** M. M. Alvarez, A. Cantoral-Sánchez, and G. Trujillo-de Santiago, “Chaotic (bio)printing in the context of drug delivery systems,” Advanced Drug Delivery Reviews, vol. 216, p. 115475, Jan. 2025, doi: https://doi.org/10.1016/j.addr.2024.115475.

**Link:** https://pubmed.ncbi.nlm.nih.gov/39561907/

**Content:**

- Chaotic (bio)printing - uses chaotic flows to create highly ordered microstructures within materials
  - Enables the precise layering of different active ingredients - may help facilitate the development of polypills with customizable release profiles
- Article will look at principles underlying chaotic flows & application in fabricating complex, multi-material constructs designed for advanced drug delivery
- Has been used to produce micro-architected hydrogel spheres in high-throughput manner - enhance versatility and efficiency of drug delivery
- Also enables creation of evolved tissue models that more accurately emulate physiological systems
- Unique advantages of chaotic printing
  - ability to fabricate tissues with organized porosity and pre-vascularized structures

1 - 3D printing in the context of drug delivery

- Potential for novel, intelligent materials with superior drug delivery capabilities & development of realistic tissue models for testing drugs and delivery systems
- In 2015, Spritam made first 3D-printed tablet approved by US FDA - drug dosages through additive manufacturing
- 3D printing has become relevant for development of tissue models for drug delivery testing
- Chaotic printing is an additive manufacturing technique
  - rapidly & efficiently fabricates microstructures within materials using chaotic flows
  - Path of a single particle in a fully chaotic system appears erratic/random
  - However, when tracking a line, curve, or surface, chaotic systems lead to the rapid formation of **highly ordered microstructures**
  - Can be used to create materials and tissue models with enhanced functionalities specifically designed for drug delivery and controlled release applications

2 - Chaotic printing: Underlying concepts and principles

- Often driven by periodic changes in boundary conditions
- Sin explains the flow
- The iteration of stretching and folding promotes the exponential development of microstructures

3 - Chaotic fabrication: most common set-ups

- Chaotic systems were primarily studied in the context of improving mixing efficiency, particularly in low agitation speed or highly viscous liquid environments
- Microarchitecture developed chaotically can be preserved through physical crosslinking strategies - eg. immersion in calcium chloride for alginate-based inks, or exposure to UV light for GelMA-based inks, resulting in a physical material construct with a high density of internal microstructures composed of multimaterial layers created by stretching and folding materials
- Miniaturized journal bearing flow is highly efficient at creating inner surfaces within solid constructs of reduced volume and long and thin hydrogel ribbons. Batch nature may limit its use in extrusion-based fabrication. To overcome this limitation, extend the concept flow-based fabrication to **continuous chaotic printing using *Kenics static mixers***
- By outfitting empty pipes with a **series** of Kenics mixing elements, typically **ranging 2 to 7** and integrating a **conical-shaped tip** at the tube outlet, chaotic printheads capable of generating chaotic flows continuously
- These printheads - **fed continuously with viscous, crosslinkable liquids** via syringe pumps, enable the controlled fabrication of complex microstructures composed of **alternating layers of materials introduced through distinct inlet ports**
- Number of layers in resulting filament determined by number of mixing elements - as each element splits and reorients the flow streams
    - s = 2^n, where s is the number of layers and n is the number of mixing elements
    - eg. printheads with 1, 2, 3, 4, 5, 6 Kenics will produce filaments with 2, 4, 8, 16, 32, and 64 intercalated layers
    - By incorporating additional top inlet ports, flexibility of these chaotic printheads is significantly enhanced, allowing to produce architected constructs with parallel and alternating layers of multiple materials
- s=alpha*2^(n-1) - number of striations for a printhead with multiple inlets; alpha represents number of inlet ports located before the first mixing element
- Chaotic printheads can be further adapted for use in electrospinning devices or Cartesian 3D printers, expanding their application range and the dimensions of the architected constructs that can be produced
- Chaotic printing can be used to generate microarchitected hydrogel spheres

4 - Chaotic printing: relevant applications to drug delivery systems

- Understanding how molecules travel through tissues or organs, target specific locations, and interact with nearby biological structures is a complex but essential task for assessing drug delivery systems
- Mimicking vascularization is very important for effective **mass transport and drug delivery**, but creating fully functional blood vessel systems is still very difficult
- With adaptations, channels of different calibers can be incorporated within the same filament
- **Sheets with lines of sacrificial material of different widths could be produced using this technology (Dean)**
- Chaotic printing is good at creating micro-layered structures efficiently and easily
- The efficacy of a drug is influenced by surface phenomena, often mediated by membranes
- Upon the addition of glucose, only the enzyme-bound section fluoresced, demonstrating the concept's potential for various molecular scenarios
- Chaotic printing enables accommodation of thin layers of materials with different affinities for water - hydrophilic & hydrophobic, with a tunable degree of interface
    - This could be used to simulate biological barriers, such as the blood-brain barrier, which is highly hydrophobic and relevant for recapitulating critical aspects of brain architecture in drug delivery research
- Cross-communication between layers of cells or materials is another important feature in *in vitro systems*
- Micro-layered design allows to more closely mimic the natural tumor microenvironment - insights into how spatial compartmentalization impacts cellular behavior and drug efficacy
- Compartmentalization of tissue constructs also plays crucial role in the alignment of cells

- Cellular alignment within multicompartmental hydrogel fibers is influenced by the spatial organization and material properties of the compartments
- Alginate (non-responsive to cells due to the lack of cell-anchoring motifs) acts as a barrier that prevents isotropic spreading, encouraging myoblast alignment along the primary direction of the filament
- Chaotic bioprinting enables precise tuning of the microenvironment to enhance cellular responses
- First configuration
    - 2 inlets used - alternating layers of a hydrogel ink loaded with 0.1% bioactive glass nanoparticles and bioink containing myoblasts
    - Limited cell development - cells spreading only on surface
- Second configuration
    - 4 inlets
    - Promoted significant cell spreading and myogenesis
- Final configuration
    - 6 inlets; higher concentration of bioglass
    - Supported cell development but with reduced efficiency than 2nd case
- Chaotic printing can be adapted to create hollow layers or channels by incorporating sacrificial materials - enhance mass transfer to inner parts of the constructs & provide physical cues for cellular growth
- Cells have been reported to prefer 2D surfaces over 3D matrices for growth

5 - Prospectives and final remarks

- Engineer smarter, more personalized drugs
- Additive manufacturing processes allows for a level of precision that can revolutionize both individualized treatments and mass-produced medications
- Can allow controlled release
- Chaotic printing can enable creation of complex, hierarchical structures tailored for specific solubility profiles, release performance, and mechanical or thermal properties

**Conclusion/Action Items:**

- This helped provide insight into the use of different numbers of Kenics, and how that affects the output
- The potential for chaotic printing seems very interesting and to have lots of potential
- Want to research more into how the device works

Advanced Drug Delivery Reviews

Chaotic (bio)printing in the context of drug delivery systems

GRAPHICAL ABSTRACT

ARTICLE INFO

ABSTRACT

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# 2025/09/18 - Novel stirring-rod-inspired mixer-integrated printhead for fabricating gradient tissue structures

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 18, 2025, 8:01 PM CDT

**Date:** 18 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Learn about kenics static mixers

**Search term:** kenics static mixer in bioprinting

**Citation:** P. Wang, Y. Sun, Z. Ma, L. Diao, H. Liu, and V. Prasad Shastri, “Novel stirring-rod-inspired mixer-integrated printhead for fabricating gradient tissue structures,” Materials & Design, vol. 229, p. 111866, Mar. 2023, doi: https://doi.org/10.1016/j.matdes.2023.111866.

**Link:** https://www.sciencedirect.com/science/article/pii/S0264127523002812

**Content:**

- Commercially available mixers can generate high fluid pressure and shear force that harm cells
- Printheads integrated with multiple discrete mixers with consistent spiral directions, performing well when introducing gaps, were used to reduce the cell pressure and shear force
- Optimal mixer design: two 1.62 mm gaps and 6-stir element mixer units sharing the same spiral structure, reduced the average fluid pressure and shear force compared to a commercial static mixer

**Conclusions/Action Items:**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 18, 2025, 7:39 PM CDT


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**Novel_stirring-rod-inspired_mixer-integrated_printhead_for_fabricating_gradient_tissue_structures.pdf (3.49 MB)**

# 2025/09/24 - Advancements in Insulin Pumps

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 31, 2025, 10:27 AM CDT

**Date:** 22 September 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Learn about how diabetes pumps/infusion devices work - pumping part & controlled release

**Search term:**

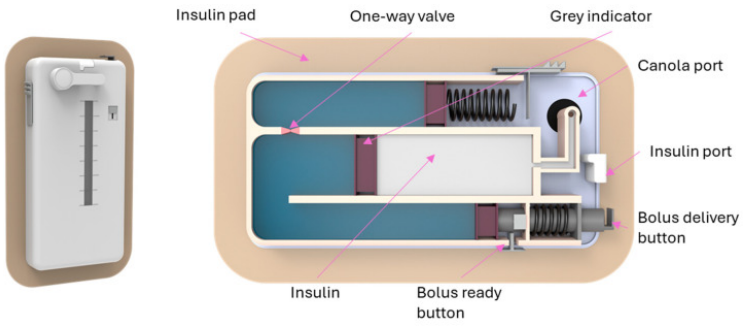
**Citation:** M. T. I. Rimon, M. W. Hasan, M. F. Hassan, and S. Cesmeci, “Advancements in Insulin Pumps: A Comprehensive Exploration of Insulin Pump Systems, Technologies, and Future Directions,” Pharmaceutics, vol. 16, no. 7, p. 944, Jul. 2024, doi: https://doi.org/10.3390/pharmaceutics16070944.

**Link:** https://pmc.ncbi.nlm.nih.gov/articles/PMC11279469/

**Content:**

- Insulin pumps can provide a very accurate and individualized method of delivering insulin compared to injections
- Quest for fully closed-loop system is ongoing, CGM has been widely adapted by many T1D patients
- This study compares modern insulin pump technologies, tracking their evolution and classification while assessing their efficacy, characteristics, and user-friendliness
- Multiple types of insulin - fast, slow, some with no peaks - that when combined can give the person the best outcome - dose before meals, help bring down sugar after, general maintenance glucose that acts as a sort of metabolic insulin
- Insulin pumps have improved in size, accuracy, and reliability from 40 years ago
- Insulin pumps originally only available in hospital while waiting for transplant
- 3 primary pump mechanisms: conventional, patch, implantable
- Modern pumps have algorithms to control how much and when insulin is released

- Traditional pump uses a stepper motor to actuate a plunger which delivers insulin
- Controlled by PCB and microcontroller
- drive mechanism consists of a lead screw (1), a plunger attached to a lead-screw follower (2), and a compression spring (3)
- If the rotation of the follower is restricted, the restoring force from the compressed spring will drive the plunger forwards, causing the lead screw to rotate
- insulin dosage can be controlled by limiting the rotation of the lead screw using a clockwork escapement mechanism (5), so that the periodic release of an escapement gear delivers a set dose of insulin
- 50:1 gearbox so one "tick" can deliver 0.1 unit of insulin



**Conclusion/Action Items:**

- Could a similar system be used? - Know how much of each material is going into each KSM, then make it in such small increments that the tube empties and at correct volume
- Could be a potential design idea if our current designs do not work

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 21, 2025, 1:16 PM CDT

pharmaceutics

MDPI

Review

# Advancements in Insulin Pumps: A Comprehensive Exploration of Insulin Pump Systems, Technologies, and Future Directions

Mohammad Tawhidul Islam Rizvan, Md Wasif Hasan, Mohammad Fuad Hassan and Sevki Cesmeci *

Department of Mechanical Engineering, Georgia Southern University, Statesboro, GA 30458, USA
* Correspondence: scesmeci@georgiasouthern.edu

**Abstract:** Insulin pumps have transformed the way diabetes is managed by providing a more accurate and individualized method of delivering insulin, in contrast to conventional injection routines. This research explores the progression of insulin pumps, following their advancement from initial ideas to advanced contemporary systems. The report proceeds to categorize insulin pumps according to their delivery systems, specifically differentiating between conventional, patch, and implantable pumps. Every category is thoroughly examined, emphasizing its unique characteristics and capabilities. A component recommendation of commercially available pumps is provided to enhance informed decision making. This section provides a thorough analysis of important specifications among various brands and models. Considered factors include basal rate and bolus dosage capabilities, reservoir size, user interface, and compatibility with other diabetes care tools, such as continuous glucose monitoring (CGM) devices and so on. This review seeks to empower healthcare professionals and patients with the essential information to improve diabetes treatment via individualized pump therapy options. It provides a complete assessment of the development, categorization, and full specification comparisons of insulin pumps.

**Keywords:** Type 1 diabetes (T1D); Type 2 diabetes (T2D); insulin; insulin pumps; patch pumps; continuous glucose monitoring; micropump

## 1. Introduction

The landscape of diabetes on a global scale is rapidly evolving, with predictions showing a significant rise in the future. Increasing from the estimated 366 million individuals affected in 2011 to a forecasted 552 million by 2030 highlights the magnitude of this epidemic, emphasizing the urgent need for significant attention and innovative solutions [1]. Type 2 diabetes mellitus (T2DM) comprises most cases, accounting for 85% to 95% globally; type 1 diabetes mellitus (T1DM) cases are increasing alarmingly in selected regions of Europe and the USA, with rates increasing by 2–3% [2]. Consequently, diabetes has become one of the most widespread noncommunicable diseases worldwide. The discovery of insulin stands as one of modern medicine's greatest achievements, revolutionizing the management of both T1DM and long-standing T2DM [3–5]. However, early insulins derived from animal pancreases, such as bovine and porcine, possessed noteworthy challenges, including immunological reactions, erratic absorption, and lipodystrophy [3]. As a result, extensive studies were conducted to overcome the obstacles that slowed down the development of insulin formulations and improve the methods used for insulin purification [6]. During the last couple of decades, fast-acting and long-acting insulin analogs were introduced, indicating a radical turning point of insulin development [3,4]. The Diabetes Control and Complication Trial (DCCT) highlighted the critical role of intensive insulin therapy (IIT) in reducing both microvascular and macrovascular complications among people with type 1 diabetes mellitus (T1DM) [3]. However, the increased risk of hypoglycemia resulting from IIT has lowered the objective of strict glycemic control [6,7]. As a result, the focus has been shifted towards creating insulin formulations that mimic the pancreas' natural production,

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# 2025/10/16 - Research on potential supplies for prototyping

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 16, 2025, 7:42 PM CDT

**Date:** 16 October 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research potential materials the group needs in order to prototype

**Search term:**

**Citation:** N/A

**Link:** https://shopuwplus.wisc.edu/catalog-suppliers/

**Content:**

- Started by listing given supplies from client - syringes, automatic syringe pusher, & tubing
- For design 1, we need pinch clamps (or something of the same function)
    - I think it would be good to get a few manual clamps if possible to test a "proof of concept" before investing more time in making the design automatable
    - There are some options on VWR and Medline, but they seem fairly expensive and the price is not visible unless logged in
    - Amazon has much cheaper clamps for the right size which I think would serve our purposes
- Also for design 1, to make it automatable, automatable clamps seem hard to find
    - Considering finding cheaper motors (eg. on Sparkfun) to prove our idea and have some simple circuit
- For design 2, we are looking for a motor to rotate the plate in between 2 parts
    - As for the mechanism, we are not too sure yet - hopefully Solidworks modeling this week will provide some direction
    - If we get the smaller motors, may try to use the motor for design 2 as well

**Conclusion/Action Items:**

- Discuss potential options with groupmates
- Work on Solidworks this week to work on design 2 further

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 16, 2025, 7:42 PM CDT

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**Supplies_for_Prototyping_-_Sheet1.pdf (88.2 kB)**

# 2025/11/14 - Articles Citing Dr. Dean's Article

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 11:04 AM CST

**Date:** 14 November 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Find articles and any relevant information from them referencing Dr. Dean's original article

**Search term:** Articles citing "Sheet-based extrusion bioprinting"

**Citation (in order of appearance):**

N. A. Mirsky et al., “Three-Dimensional Bioprinting: A Comprehensive Review for Applications in Tissue Engineering and Regenerative Medicine,” Bioengineering, vol. 11, no. 8, pp. 777–777, Jul. 2024, doi: https://doi.org/10.3390/bioengineering11080777.

Y. Kang, D. M. Kalaskar, and D. J. Player, “In vitro models of muscle spindles: From traditional methods to 3D bioprinting strategies,” Journal of tissue engineering, vol. 16, p. 20417314251343388, Autumn 2025, doi: https://doi.org/10.1177/20417314251343388.

Z. Yang et al., “CeyeHao: AI-driven microfluidic flow programming with hierarchically assembled obstacles and receptive field–augmented neural network,” Science Advances, vol. 11, no. 31, Jul. 2025, doi: https://doi.org/10.1126/sciadv.adx2826.

X. Mei et al., “Integrating microfluidic and bioprinting technologies: advanced strategies for tissue vascularization,” Lab on a Chip, 2025, doi: https://doi.org/10.1039/d4lc00280f.

A. Priester, J. Yeng, Y. Zhang, D. Christofferson, R. Wang, and A. J. Convertine, “PISA printing perfusable microcapillaries,” Biomaterials Science, vol. 13, no. 19, pp. 5358–5368, 2025, doi: https://doi.org/10.1039/d5bm00547g.

R. Chand, K. Kamei, and Sanjairaj Vijayavenkataraman, “Advances in Microfluidic Bioprinting for Multi-material Multi-cellular Tissue Constructs,” Cell engineering connect., vol. 1, Jan. 2025, doi: https://doi.org/10.69709/cellengc.2024.111335.

K. O. Rojek et al., “Engineering of interconnected microcapillary networks at the mesoscale via magnetic assembly of endothelial-cell ‘seeds,’” bioRxiv (Cold Spring Harbor Laboratory), May 2025, doi: https://doi.org/10.1101/2025.05.20.655072.

S. Song, T. Agarwal, S. Guo, S. Y. Hann, J. D. Lee, and L. G. Zhang, “Precise cell stratification in alginate/gelatin methacrylate based 3D construct using coaxial chaotic bioprinting,” International Journal of Biological Macromolecules, vol. 330, p. 148102, Oct. 2025, doi: https://doi.org/10.1016/j.ijbiomac.2025.148102.

**Link (in order of appearance):**

https://pmc.ncbi.nlm.nih.gov/articles/PMC11351251/

https://pmc.ncbi.nlm.nih.gov/articles/PMC12290365/

https://pmc.ncbi.nlm.nih.gov/articles/PMC12309690/

https://pubmed.ncbi.nlm.nih.gov/39775452/

https://pubs.rsc.org/en/content/articlelanding/2025/bm/d5bm00547g

https://scifiniti.com/3105-3866/1/2025.0002

https://www.biorxiv.org/content/10.1101/2025.05.20.655072v1

https://doi.org/10.1101/2025.05.20.655072

https://www.sciencedirect.com/science/article/abs/pii/S0141813025086593

**Content:**

1. Three-Dimensional Bioprinting: A Comprehensive Review for Applications in Tissue Engineering and Regenerative Medicine
    - Traditional syringe-based bioprinting techniques have struggled to consistently produce perfusable constructs with hierarchical branching at microvascular resolutions
    - Hooper et al. attempted to address this drawback by introducing a novel bioprinting device that allows for the mid-extrusion control of material and channel properties, effectively producing wide cell-laden hydrogel sheets capable of producing branching channels encompassing the resolution range of microvascular vessels. The customizable hydrogel sheets maintained over 90% cell viability in vitro.
2. In vitro models of muscle spindles: From traditional methods to 3D bioprinting strategies
    - Extrusion-based bioprinting is also recognised for its scalability and capability for multi-material bioprinting. This can be achieved by integrating multiple nozzles within a single system, with customisable print heads and nozzle types tailored to produce specific outcomes.
    - In recent years, kenics static mixers (KSMs) have been introduced in extrusion-based printing, which allows for the production of filaments with two or more channels of different biomaterials within each strand
    - the resolution of standard extrusion bioprinting is relatively low (~100 μm), as it is determined by the nozzle's diameter
    - These biomaterials allow for the formation of perfusable microchannels within bioprinted muscle constructs, facilitating local oxygenation, nutrient transport and improving cell viability over extended culture period
3. CeyeHao: AI-driven microfluidic flow programming with hierarchically assembled obstacles and receptive field–augmented neural network
    - it holds great potential for a wide range of microfluidic applications where precise control over spatial flow distribution is required. Specifically, we envision the use of CeyeHao in extrusion-based bioprinting for its simple and compact microchannel structure, which can be easily integrated into printing nozzles for filament or sheet-based bioprinting
4. Integrating microfluidic and bioprinting technologies: advanced strategies for tissue vascularization
    - to fabricate complex and functional vascular systems, sheet-based extrusion bioprinting with GelMA hydrogels represents a substantial advancement
    - By utilizing endothelial cells and pericytes, sheet-based extrusion bioprinting enabled microvascular construction. EBB can be further utilized to fabricate vascular tissues
5. PISA printing perfusable microcapillaries
    - Abstract: Polymerization-induced self-assembly (PISA) printing combines reversible addition–fragmentation chain transfer (RAFT) polymerization with digital light projection (DLP) photolithography to create high-resolution three-dimensional structures without permanent covalent crosslinks. Here, we intoduce a simplified, one-pot, purification-free synthesis for multi-chain transfer agent (multi-CTA) scaffolds that spontaneously form robust physical networks durnig printing, stabilized by interparticle bridges and knots. By tuning solvent-resin chemistry and polymer composition, we achieved precise control over nanoscale morphologies and selective distribution behaviors. This approach was demonstrate through successful fabrication of perfusable microvascular networks and open-channel polydimethylsiloxane (PDMS) microfluidic devices, where sacrificial scaffolds dissolved cleanly to yield stable microchannels. Collectively, these findings enhance the accessibliity, flexibility, and functionality of PISA printing, offering an efficient and adaptable platform for microfabrication, rapid prototyping, and advance d tissue engineering applications.
        - (Whole article not available)
6. Advances in Microfluidic Bioprinting for Multi-Material Multi-Cellular Tissue Constructs
    - Hooper et al. [32] introduced CEVIC (Continuously Extruded Variable Internal Channeling) device that makes use of a KSM printhead for high-throughput sheet-based extrusion bioprinting. Besides these, other active and passive (including chaotic) mixer designs have been extensively studied for other microfluidic applications and merit further investigation for use in microfluidic bioprinting
7. Engineering of interconnected microcapillary networks at the mesoscale via magnetic assembly of endothelial-cell 'seeds'

- The currently available methods of EC patterning, such as extrusion bioprinting [13-18] typically suffer from low reproducibility and limited angiogenic potential of the fabricated constructs. EC-spheroid based bioprinting [19] provides further improvements, but also faces unresolved issues such as nozzle clogging or spheroid deformation and breakup during printing

8. Precise cell stratification in alginate/gelatin methacrylate based 3D construct using coaxial chaotic bioprinting
    - Hooper et al. introduced an innovative continuously extruded variable internal channeling device based on the principles of chaotic printing. This approach utilized multiple KSM printheads bundled together to collectively fabricate hydrogel sheets with spatially patterned layers designed to mimic the architecture of microvascular tissue. By adjusting the number of KSM elements in sequence, the resulting patterns within the hydrogel sheets could be precisely modulated.

**Conclusion/Action Items:**

- This information is found through Research Gate and looking at different articles that have cited the original article. Do not have access to all of them, but it is good to get a sense of what is out there related to our topic

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 10:07 AM CST

bioengineering

MDPI

Review

# Three-Dimensional Bioprinting: A Comprehensive Review for Applications in Tissue Engineering and Regenerative Medicine

Nicholas A. Minky [1,†], Quinn T. Ehlen [1,†], Jason A. Greenfield [2], Michael Antonietti [3], Blair V. Staehr [1], Vasudev Vivekanand Nayak [4], Daniel Pelaez [5], David T. Tse [3], Lukasz Witek [4,6,*], Sylvia Dunnett [7] and Paula G. Coelho [4,7,*]

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[4] Biomaterials Division, NYU Dentistry, New York, NY 10010, USA
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† These authors contributed equally to this work.

**Abstract:** Since three-dimensional (3D) bioprinting has emerged, it has continuously to evolved as a revolutionary technology in surgery, offering new paradigms for reconstructive and regenerative medical applications. This review highlights the integration of 3D printing, specifically bioprinting, across several surgical disciplines over the last five years. The methods employed encompass a review of recent literature focusing on innovations and applications of 3D-bioprinted tissues and/or organs. The findings reveal significant advances in the creation of complex, customized, multicellular constructs that mimic natural tissue characteristics, which are crucial for surgical interventions and patient-specific treatments. Despite the technological advances, the paper introduces and discusses several challenges that remain, such as the standardization of bioprinted tissues, integration with the host tissue, and the long-term viability of bioprinted organs. The review concludes that while 3D bioprinting holds substantial promise for transforming surgical practices and enhancing patient outcomes, ongoing research, development, and a clear regulatory framework are essential to fully realize potential in future clinical applications.

**Keywords:** 3D bioprinting; regenerative medicine; tissue engineering; surgical implants; bioinks; orthopedic surgery; plastic and reconstructive surgery; ophthalmology

## 1. Introduction

Three-dimensional (3D) printing, also known as additive manufacturing (AM), is a revolutionary "bottom-up" manufacturing technique used to fabricate customized physical objects (devices) and bulk products [1]. Since its introduction in the early 1980s, 3D printing technology has experienced rapid progress. Consequently, the advancement of affordable 3D printing equipment and the availability of open-source software have greatly enhanced accessibility. The rising popularity of 3D printing over the past two decades in different industries, including the aerospace, automotive, dental, and medical industries, can be attributed to its versatility, relative ease of use, and capacity to manufacture complex shapes and structures. It is worth mentioning that the medical industry has been slow to adopt the use of 3D printing relative to other industries, partly owing to strict standards including

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STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 10:45 AM CST

Engineering of interconnected microcapillary networks at the mesoscale via magnetic assembly of endothelial-cell 'seeds'.

Katarzyna O. Rejek [1], Antoni Wrzus [2], Fabio Mainiheri [1,3], Konrad Gizyński [2], Maria Grazia Ceraolo [4], Claudia Bearzi [3], Roberto Rizzi [3], Piotr Szymczak [2] and Jan Guzowski [1,*]

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5. Department of Medical-Surgical Sciences and Biotechnologies, Sapienza University, C.so della Repubblica 79, 04100 Latina, Italy

* Corresponding author: Jan Guzowski, jguzowski@ichf.edu.pl

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STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 10:45 AM CST

Cell Therapy & Engineering Connect

SCIFINITI

Review Article

Advances in Microfluidic Bioprinting for Multi-Material Multi-Cellular Tissue Constructs

Rashik Chand[1,2], Kenichiro Kamei[1,3,4], Sanjai J. Vijayakumaran[1,2,5,*]

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Article History
Submitted: December 12, 2024 Accepted: January 09, 2025 Published: February 25, 2025

Abstract

3D bioprinting enables fabrication of cell-laden hydrogels into complex, biomimetic tissues. However, achieving the spatial and functional heterogeneity of native tissues still poses significant challenges. Microfluidics has emerged as a complementary technology, offering precise control over material flow, mixing, and deposition at the microscale. This review highlights the integration of microfluidics with 3D bioprinting, with a particular focus on the development of advanced "printhead-on-a-chip" systems that enable real-time material switching, gradient formation, and enhanced resolution—capabilities not achievable with conventional bioprinting methods. Innovations across extrusion-, droplet-, and vat-based bioprinting modalities are explored, showcasing the transformative potential of microfluidics in creating multifunctional cell-laden constructs with biomimetic architectures. Applications in tissue heterogeneity, vascularization, tumor microenvironments, microfiber cell culture technology, and organ-on-a-chip systems are discussed, underscoring their role in advancing tissue engineering, disease modeling, and drug discovery. Future directions address the need for scalability, standardization, and simplified workflows that enhance accessibility for broader adoption of microfluidic bioprinting.

Keywords
bioprinting; microfluidics; 3D printing; tissue engineering

## 1. Introduction

3D bioprinting is an additive manufacturing technique that constructs cell-laden hydrogels, or bioinks, into functional tissue structures using a layer-by-layer approach [as in extrusion bioprinting] or voxel-by-voxel approach [as in volumetric bioprinting]. The primary objective of 3D bioprinting is to create complex, heterogeneous, and biomimetic tissues that closely resemble the architecture and functionality of native biological tissues. Achieving this goal requires the ability to reproduce the spatial and functional heterogeneity found in natural tissues, which often demands the fabrication of multi-material and multi-cellular constructs. This complexity poses unique challenges in material compatibility, cellular integration, and structural stability, particularly when striving to replicate intricate tissue architectures such as vascular networks or organ-specific microenvironments.

Several bioprinting approaches have been developed to address these challenges, each with distinct advantages and limitations. Common techniques include laser-based bioprinting, droplet-based methods, extrusion-based bioprinting, and various lithography bioprinting [1]. These methods vary in their precision, scalability, compatibility with bioinks, and suitability for specific applications. However, the discussion of such techniques is beyond the scope of this review. The challenges associated with multi-material, multi-cellular tissue fabrication

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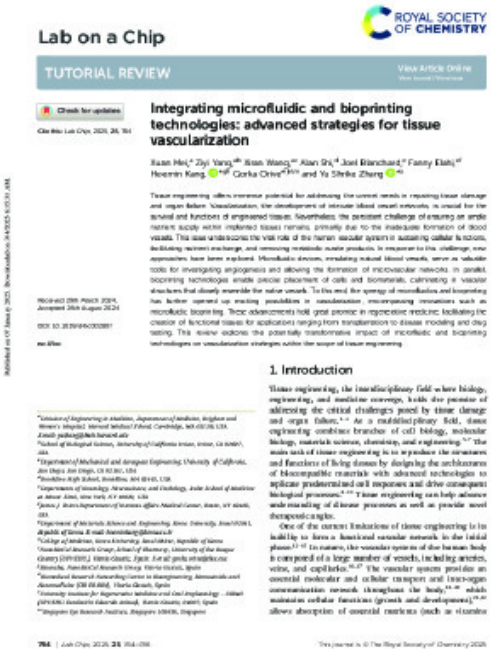
STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 10:45 AM CST



Lab on a Chip

TUTORIAL REVIEW

Integrating microfluidic and bioprinting technologies: advanced strategies for tissue vascularization

1. Introduction

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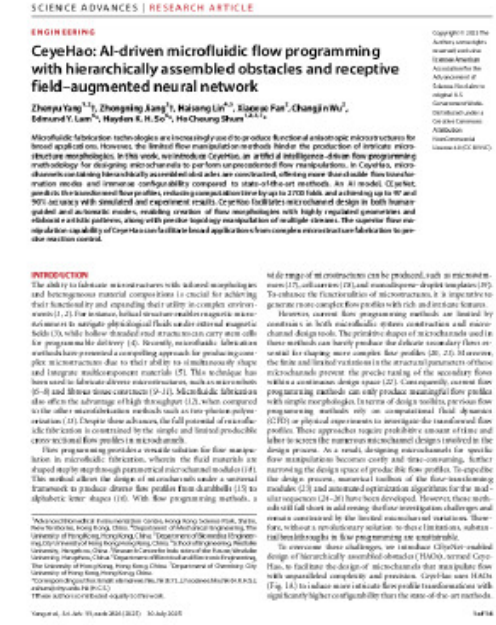

SCIENCE ADVANCES | RESEARCH ARTICLE

ENGINEERING

CeyeHao: AI-driven microfluidic flow programming with hierarchically assembled obstacles and receptive field–augmented neural network

INTRODUCTION

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STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 10:45 AM CST

*In vitro* models of muscle spindles: From traditional methods to 3D bioprinting strategies

Yuannan Kang[1], Deepak M. Kalaskar[2] and Darren J. Player[1]

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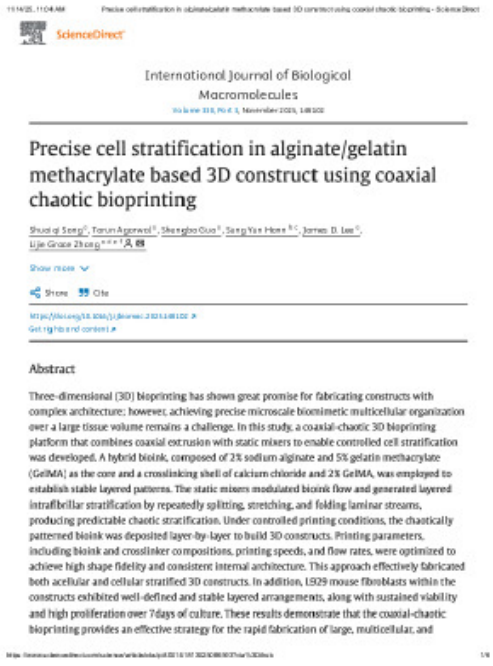
STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 14, 2025, 11:05 AM CST



ScienceDirect

International Journal of Biological Macromolecules

Precise cell stratification in alginate/gelatin methacrylate based 3D construct using coaxial chaotic bioprinting

Abstract

Three-dimensional (3D) bioprinting has shown great promise for fabricating constructs with complex architecture; however, achieving precise microscale biomimetic multicellular organization over a large tissue volume remains a challenge. In this study, a coaxial-chaotic 3D bioprinting platform that combines coaxial extrusion with static mixers to enable controlled cell stratification was developed. A hybrid bioink, composed of 2% sodium alginate and 5% gelatin methacrylate (GelMA) as the core and a crosslinking shell of calcium chloride and 2% GelMA, was employed to establish stable layered patterns. The static mixers modulated bioink flow and generated layered intrafibrillar stratification by repeatedly splitting, stretching, and folding laminar streams, producing predictable chaotic stratification. Under controlled printing conditions, the chaotically patterned bioink was deposited layer-by-layer to build 3D constructs. Printing parameters, including bioink and crosslinker compositions, printing speeds, and flow rates, were optimized to achieve high shape fidelity and consistent internal architecture. This approach effectively fabricated both acellular and cellular stratified 3D constructs. In addition, L929 mouse fibroblasts within the constructs exhibited well-defined and stable layered arrangements, along with sustained viability and high proliferation over 7 days of culture. These results demonstrate that the coaxial-chaotic bioprinting provides an effective strategy for the rapid fabrication of large, multicellular, and

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**Precise_cell_stratification.pdf (264 kB)**

# 2025/11/23 - pre-osteoblast morphology

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 23, 2025, 9:27 PM CST

**Date:** 23 November 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research on how pre-osteoblasts behave after freezing

**Search term:** how fast do pre-osteoblast cells look spindle after unfreezing

**Citation:** A. Georgopoulou, M. Kaliva, M. Vamvakaki, and M. Chatzinikolaidou, “Osteogenic Potential of Pre-Osteoblastic Cells on a Chitosan-graft-Polycaprolactone Copolymer,” Materials, vol. 11, no. 4, p. 490, Mar. 2018, doi: https://doi.org/10.3390/ma11040490.

**Link:** https://pmc.ncbi.nlm.nih.gov/articles/PMC5951336/

**Content:**

- Morphology of the MC3T3-E1 pre-osteoblastic cells over days 2-7 were investigated
- Day 2 - a few adherent cells on surface observed; cells appear elongated with spindle-shape
- After 7 days, pre-osteoblast extensively proliferate and expand to form thick layer; cells are flat

After checking our cells today (2 days after seeding frozen cells), the morphology some round, some oddly triangle, a few spindles. We were concerned because the media also appeared slightly cloudy, which we were concerned might be contributing to lack of cell adhesion and growth.

While this article is on a different surface than we used, it still gives an overview of how the cells will likely behave.

**Conclusion/Action Items:**

- Check on cells tomorrow (Monday) - check confluency, morphology, contamination
    - Make plan what to do based on observations

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 23, 2025, 9:26 PM CST

materials

Article

**Osteogenic Potential of Pre-Osteoblastic Cells on a Chitosan-*graft*-Polycaprolactone Copolymer**

Anthie Georgopoulou [1], Maria Kaliva [1,2], Maria Vamvakaki [1,2] and Maria Chatzinikolaidou [1,*]

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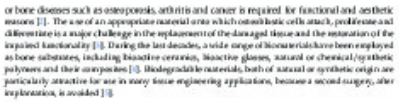
Received: 5 February 2018; Accepted: 21 March 2018; Published: 26 March 2018

**Abstract:** A chitosan-graft-polycaprolactone (CS-g-PCL) copolymer synthesized via a one-step process was evaluated as a potential biomaterial for the adhesion and growth of MC3T3-E1 pre-osteoblastic cells. A strong adhesion of the MC3T3-E1 cells with a characteristic spindle-shaped morphology was observed from the first days of cell culture onto the copolymer surfaces. The viability and proliferation of the cells on the CS-g-PCL surfaces, after 3 and 7 days in culture, were significantly higher compared to the cells cultured on the tissue culture treated polystyrene (TCPS) control. The osteogenic potential of the pre-osteoblastic cells cultured on CS-g-PCL surfaces was evaluated by determining various osteogenic differentiation markers and was compared to the TCPS control surface. Specifically, alkaline phosphatase activity levels show significantly higher values at both time points compared to TCPS, while secreted collagen into the extracellular matrix was found to be higher on day 7. Calcium biomineralization deposited into the matrix is significantly higher for the CS-g-PCL copolymer after 14 days in culture, while the levels of intracellular osteopontin were significantly higher on the CS-g-PCL surfaces compared to TCPS. The enhanced osteogenic response of the MC3T3-E1 pre-osteoblasts cultured on CS-g-PCL reveals that the copolymer can deprive the cell functions towards bone tissue formation and is thus an attractive candidate for use in bone tissue engineering.

**Keywords:** biomaterial; chitosan; polycaprolactone; osteogenic potential; bone tissue engineering; pre-osteoblastic cells

1. Introduction

Bone is a highly vascularized organ, providing shape, mechanical support and protection to vital organs and facilitating movement [1]. The functional restoration of bone defects resulting from trauma



or bone diseases such as osteoporosis, arthritis and cancer is required for functional and aesthetic reasons [1]. The use of an appropriate material onto which osteoblastic cells attach, proliferate and differentiate is a major challenge in the replacement of the damaged tissue and the restoration of the impaired functionality [1]. During the last decades, a wide range of biomaterials have been employed as bone substitutes, including bioactive ceramics, bioactive glasses, natural or chemical/synthetic polymers and their composites [1]. Biodegradable materials, both of natural or synthetic origin are particularly attractive for use in many tissue engineering applications, because a second surgery, after implantation, is avoided [1].

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**Osteogenic_Potential_of_Pre-Osteoblastic_Cells.pdf (14.1 MB)**

# 2025/11/24 - ISO 10993-5

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 24, 2025, 6:03 PM CST

**Date:** 24 November 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research on ISO 10993-5

**Search term:** ISO 10993-5

**Citation:** “A Practical Guide to ISO 10993-5: Cytotoxicity,” www.mddionline.com. https://www.mddionline.com/testing/a-practical-guide-to-iso-10993-5-cytotoxicity

**Link:** https://www.mddionline.com/testing/a-practical-guide-to-iso-10993-5-cytotoxicity

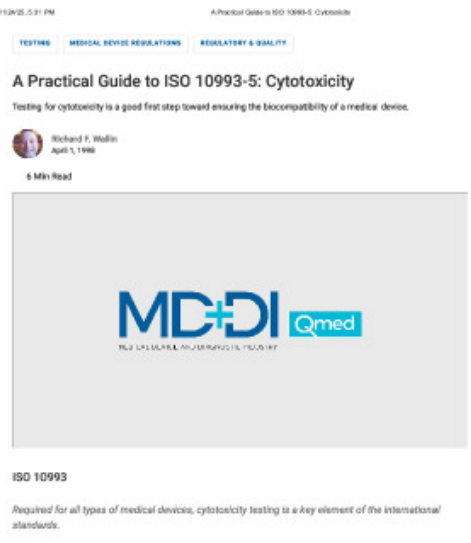
**Content:**

- Important for cytotoxicity
- Ensure device biocompatibility by identifying several types of tests for use in selecting device materials
- Standard presents a number of test methods designed to evaluate acute biological effects
- In standard cytotoxicity test methods, cell monolayers grown to near confluence in flasks then exposed to test or controls by means of fluid extracts
- Fluid extract applied to cells and incubated at 37C and periodically removed for microscopic examination along times over potentially 3 days - cells observed for visible signs of toxicity
- Cytotoxicity testing is rapid, standardized, sensitive, and inexpensive means to determine

**Conclusion/Action Items:**

- Dr. Dean had asked if we were using this ISO for testing cells, so I wanted to know what this ISO was and how to apply it
- Not our goal this semester, but can consider it next semester

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 24, 2025, 5:32 PM CST



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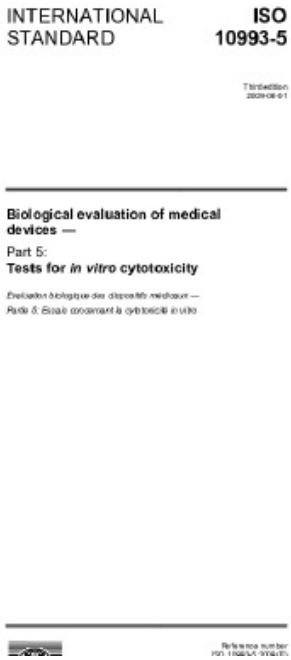
**A_Practical_Guide_to_ISO_10993-5__Cytotoxicity.pdf (464 kB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 24, 2025, 5:32 PM CST



INTERNATIONAL STANDARD **ISO 10993-5**

Third edition

**Biological evaluation of medical devices —**

Part 5:
**Tests for *in vitro* cytotoxicity**

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# 2025/11/24 - TUNEL Assay

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 24, 2025, 6:19 PM CST

**Date:** 24 November 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research on TUNEL Assay

**Search term:** TUNEL Assay

**Citation:** “TUNEL Assays | Thermo Fisher Scientific - US,” Thermofisher.com, 2024. https://www.thermofisher.com/us/en/home/life-science/cell-analysis/cell-viability-and-regulation/apoptosis/tunel-assays.html

**Link:** https://www.thermofisher.com/us/en/home/life-science/cell-analysis/cell-viability-and-regulation/apoptosis/tunel-assays.html

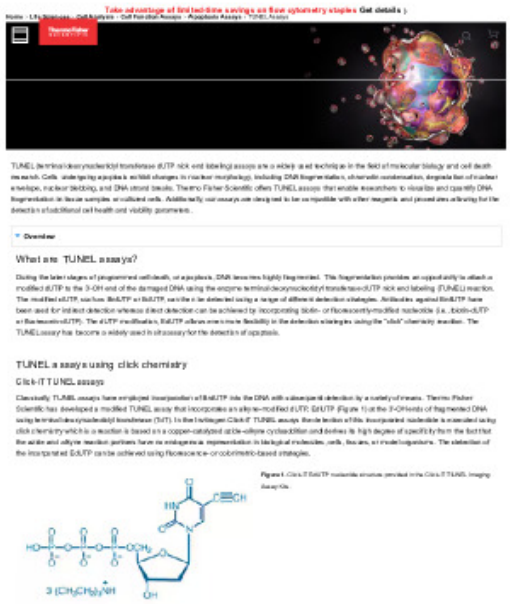
**Content:**

- When cells undergo apoptosis, nuclear morphology changes, including DNA fragmentation, chromatin condensation, degradation of nuclear envelope, nuclear blebbing, and DNA strand breaks
- During later stages of apoptosis, DNA becomes highly fragmented
    - Fragmentation provides opportunity to attach a modified dUTP to the 3'-OH end of the damaged DNA using enzyme to nick the end labeling
- Modified dUTP can be detected using a range of detection strategies
- Antibodies can be used for indirect detection, where direct detection can be achieved by incorporating modified nucleotides
- dUTP modification allows more flexibility in detection

**Conclusion/Action Items:**

- This could be a possible way to test cells, but seems to be more expensive and harder to access so that is a consideration
- Can discuss possibility for next semester for further cell testing

STEPHANIE VIGMOND (vigmond@wisc.edu) - Nov 24, 2025, 6:20 PM CST



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**TUNEL_Assays___Thermo_Fisher_Scientific_-_US.pdf (3.41 MB)**

# 2025/12/13 - Vascularized bone grafts upper extremity

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:27 PM CST

**Date:** 13 December 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research vascularizing bone grafts

**Search term:** Vascularizing Bone Graft

**Citation:** G. Petrella, D. Tosi, Filippo Pantaleoni, and R. Adani, "Vascularized bone grafts for post-traumatic defects in the upper extremity," Archives of Plastic Surgery, vol. 48, no. 01, pp. 84–90, Jan. 2021, doi: https://doi.org/10.5999/aps.2020.00969.

**Link:** https://pmc.ncbi.nlm.nih.gov/articles/PMC7861969/

**Content:**

- Vascularized fibular grafts (VFGs) are mainly used in humerus, radius or ulna in cases of persistent non-union where traditional bone grafting failed or for bone defects **larger than 6 cm**
- Aim of study is to illustrate the use of VFGs to treat large post-traumatic bone defects and osteomyelitis located in upper extremity
- Autologous bone grafts show excellent histocompatibility, osteoconductivity, osteoinductivity, and osteogenicity
- Bone graft material is progressively revascularized and finally reabsorbed, allowing new living bone to form - new bone is then incorporated and remodeled into the host skeleton
- VBGs are harvested with their vascular supply and are therefore immediately viable
- Living bone graft enables straightforward and rapid fracture healing by serving as a source of osteogenic cells, promoting vascularization, eliminating infection, and enhancing intrinsic stability at the non-union site
- Fixation method should be chosen that optimizes the local blood supply and supplements and protects the implanted grafts

**Conclusion/Action Items:**

- This article is mainly about bone grafts that come with vascularization - our project is focused on providing the vascularization for bone grafts that do not come with a blood supply already, so not the most relevant for our purposes
- Will continue to try to research possible ways to vascularize bone grafts without already having blood supply

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:14 PM CST


APS
Archives of Plastic Surgery

Hand/Peripheral Nerve
Review Article

Vascularized bone grafts for post-traumatic defects in the upper extremity

Giovanna Petrella, Daniele Tosi, Filippo Pantaleoni, Roberto Adani

INTRODUCTION

Bone grafting is required for numerous bone defects, including those in the upper extremity with non-union or delayed union of a fracture after high-energy trauma associated with significant bony tissue loss, as well as in cases of infection. Bone grafting, external fixation, and compression plates associated with non-vascularized bone grafts [ VBGs] are standard tools for the treatment of humerus and radius-ulna diaphyseal bony non-union and lead to good results in most cases. Non-union is frequently caused by poor technique of osteosynthesis with unsatisfactory skeletal fixation. In addition, bone nailing is contraindicated when there is evidence of an existing or recurring infection, as occurs with conventional bone grafts. Failure is frequently observed in bony defects greater than 6 cm.

Non-VBGs have multiple distinct characteristics that stimulate bone healing. The effectiveness of materials used for grafts is determined based on their osteogenicity, osteoinductivity, and osteoconductivity [1]. It is also mandatory to take into account the mechanical strength and vascular supply to the bone graft material (Table 1). Autologous bone grafts show excellent biocompatibility, osteoconductivity, osteoinductivity and osteogenicity. therefore, they enable bone incorporation into the adjacent host site through the process of "creeping substitution," for





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**Vascularized_bone_grafts_upper_extremity.pdf (3.92 MB)**

# 2025/12/13 - Fabricating vascularized, anatomically accurate bone grafts using 3D bioprinted sectional bone modules

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:44 PM CST

**Date:** 13 December 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research vascularizing bone grafts

**Search term:** Adding vascularization to bone grafts

**Citation:** B. E. Grottkau, Z. Hui, C. Ran, and Y. Pang, “Fabricating vascularized, anatomically accurate bone grafts using 3D bioprinted sectional bone modules, in-situ angiogenesis, BMP-2 controlled release, and bioassembly,” Biofabrication, vol. 16, no. 4, p. 045008, Jul. 2024, doi: https://doi.org/10.1088/1758-5090/ad5f56.

**Link:** https://iopscience.iop.org/article/10.1088/1758-5090/ad5f56

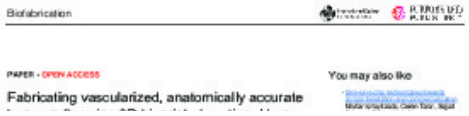
**Content:**

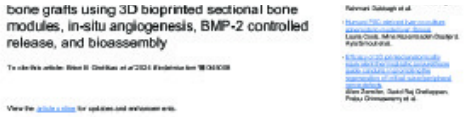
- Ideal bone graft should have high mechanical strength, osteogenic properties, and pre-vascularization
- Both top-down and bottom-up approaches face challenges in fulfilling these requirements
- This paper 3D printed a series of rigid, thin, sectional, porous scaffolds from a biodegradable polymer, tailored to the dimensions of a femur bone shaft
- Autographs, allografts, and synthetic material implantation have several drawbacks and limitations
    - Both allografts and synthetic materials lack active cellular components or vasculature, which may lead to delayed healing or non-union
- Ideal bone graft should contain both osteogenic components and vasculature
- Vascularization facilitates nutrient supply, waste removal, and introduction of osteoblasts for bone construction and remodeling
- Often preferred to pre-vascularize bone grafts in vitro before implantation
- Bottleneck lies in establishing efficient microvasculature within a clinically implantable scaffold
    - One obstacle is the lack of effective methods to generate microvasculature; sprouting from endothelial cell aggregates is among most common and effective ways for generating microvasculature in vitro - minute and delicate, making process challenging and inefficient
- Sectional modular bone approach - designed to be small in one axis, effectively overcoming the limitations of traditional techniques

**Conclusion/Action Items:**

- This appears to be another method for vascularizing bone grafts, although the bone graft is bigger than our target size (currently mouse bones, later human jaw bone)
- It is useful to see current methods out there and ways they are struggling to vascularize - where we can fit in

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:42 PM CST




bone grafts using 3D bioprinted sectional bone modules, in-situ angiogenesis, BMP-2 controlled release, and bioassembly

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**Fabricating_vascularized_bone_grafts_using_3D_bioprinted_sectional_bone_modules.pdf (3.05 MB)**

# 2025/12/15 - Together but not scrambled: A perspective on chaotic printing/bioprinting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 7:45 PM CST

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research chaotic printing

**Search term:** Scholarly article with primer on chaotic printing for engineering bone constructs

**Citation:** Grissel Trujillo-de Santiago and Mario Moisés Alvarez, “Together but not scrambled: A perspective on chaotic printing/bioprinting,” Aggregate, Apr. 2024, doi: https://doi.org/10.1002/agt2.548.

**Link:** https://onlinelibrary.wiley.com/doi/full/10.1002/agt2.548

**Content:**

- Chaotic printing - stretching, folding, and mixing of fluid particles in a flow
- Multilayered multimaterial constructs in a single step, with 1 printhead, and at a higher resolution
- Resolution determined by the flow = repeated splitting & reorientation of fluids induced by the static mixing elements hosted in chaotic printheads produces thinner and thinner layers
- KSMs - can be operated continuously; printing head that can be adapted to perform Cartesian 3D extrusion bioprinting, allowing the fabrication of hierarchical architectures
    - Allows continuous extrusion of flowing inks; mixing elements
    - Each element rotated 90 degrees and function as flow dividers that split the flow streams into 2 at each element
    - Can be mathematically modeled & predicted
    - Distance between layers may determine mechanical strength, capacitance, or resistance of composites
    - In continuous chaotic printing, the resolution (size of features) is not dictated by the diameter of the nozzle (as in regular 3D printing) but by the iterative deformation of the fluid to create progressively thinner layers - important for bioprinting
- Chaotic bioprinting, high resolution without sacrificing cell viability because no shear stress
- Dictated by number of layers produced by passing of flow streams
- KSM can be modified by: changing number of mixing elements, increasing number of inlet ports, placing them in and along; by activating or deactivating flow through inlet ports
- Ideally choose inks that behave as Newtonian fluid when passing through KSM and have same viscosity

**Conclusion/Action Items:**

- This article contains mostly information we know of chaotic printing, but is good to learn about

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 7:45 PM CST

PERSPECTIVE

Aggregate WILEY

Together but not scrambled: A perspective on chaotic printing/bioprinting

Grissel Trujillo-de Santiago | Mario Moisés Alvarez

Abstract

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**Aggregate_-_2024_-_Trujillo_de_Santiago_-_Together_but_not_scrambled_A_perspective_on_chaotic_printing_bioprinting.pdf (9.18 MB)**

# 2025/12/15 - Plug-and-Play chaotic printing

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 7:59 PM CST

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research chaotic printing

**Search term:** Plug-and-play multimaterial chaotic printing/bioprinting to produce radial and axial micropatterns in hydrogel filaments

**Citation:** Carlos Fernando Ceballos-González et al., “Plug-and-Play Multimaterial Chaotic Printing/Bioprinting to Produce Radial and Axial Micropatterns in Hydrogel Filaments,” Advanced Materials Technologies, vol. 8, no. 17, Jul. 2023, doi: https://doi.org/10.1002/admt.202202208.

**Link:** https://advanced.onlinelibrary.wiley.com/doi/full/10.1002/admt.202202208

**Content:**

- Challenge: layered multi-material patterns that transition within the same structure
- Potential solution:
  - Modification of chaotic printing set up (= plug & play system) - number of KSM elements & inlets and inlet positions
  - Activation/deactivation of ink flow through each inlet
  - Feeding of inks through side ports can be activated or deactivated during extrusion
- Computational fluid dynamics simulations can predict thickness of layers or position with respect to other layers - ANSYS Fluent
- pre-vascularized scaffolds experiment
  - Porous constructs use of lateral ports to feed fugitive materials leads to the fabrication of channels of different calibers. The 1-step fabrication of channels of different calibers within the same construct may be relevant for the design of realistic hierarchical vasculature
  - Resemble capillary system

**Conclusion/Action Items:**

- The actual incorporation of the chaotic printhead in Cartesian 3D bioprinting has been addressed but it is not still optimized

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 8:00 PM CST

RESEARCH ARTICLE

Editor's Choice

Plug-and-Play Multimaterial Chaotic Printing/Bioprinting to Produce Radial and Axial Micropatterns in Hydrogel Filaments

Carlos Fernando Ceballos-González, Edna Johana Bolívar-Monsalve, Diego Alonso Quevedo-Moreno, Carolina Chávez-Madero, Silvana Valdespino-Marín, Li Lu Lam-Aguilar, Óscar Emmanuel Solís-Pérez, Ariel Cantoral-Sánchez, Mara Neher, Estefanía Tzar-García, Yu Shrike Zhang, Carmine Gentile, Aldo R. Boccaccini, Mario Moisés Alvarez,* and Grissel Trujillo-de Santiago*

1. Introduction

[Download]

**Adv_Materials_Technologies_-_2023_-_Ceballos_González_-_Plug_and_Play_Multimaterial_Chaotic_Printing_Bioprinting_to_Produce.pdf (14.7 MB)**

# 2025/12/15 - Engineering vascularization in hydrogel constructs

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 8:09 PM CST

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Research bioprinting vasculature

**Search term:** Chaotic bioprinting vasculature for tissue engineering

**Citation:** A. Cavero-Arrivasplata et al., “Multimaterial chaotic printing of reinforced and prevascularized hydrogel filaments: Fabrication of mechanical robust constructs for long-term muscle tissue culture,” Biomaterials science, vol. 13, no. 23, pp. 6598–6612, 2025, doi: https://doi.org/10.1039/d4bm01674b.

**Link:** https://pubmed.ncbi.nlm.nih.gov/40787729/

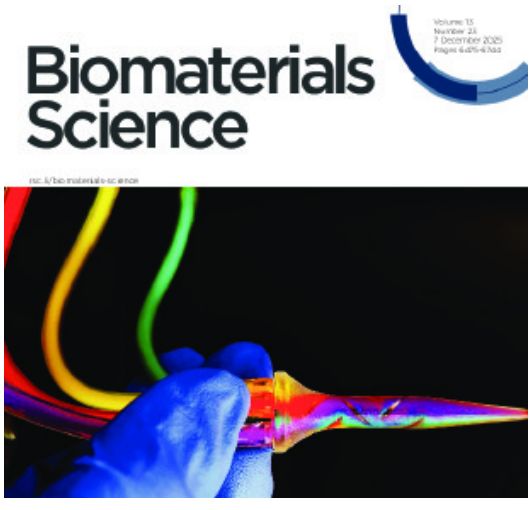
**Content:**

- Challenge: fabricating a hydrogel that is porous enough to mimic vascular channels & mechanically stable for long-term cell culture
- 3 distinct inks: structural (scaffolding) ink, sacrificial ink, cell-friendly ink
- This study - creating a construct that was stronger (elastic modulus = 12.8 kPa) & provided channels that supported cell culture up to 21 days
- Cell-laden compartments were adjacent to sacrificial layers, with inter-layer distances not exceeding 200 um to prevent mass transfer limitations that could impair cell viability
- Flow conditions - as the number of materials increased, the flow rate needed to decrease to produce fibers with distinct material compartments
- Selection of proper flow rates ensured that the inks behaved as Newtonian fluids, resulting in microstructures mechanically stable fibers
- Fibers led to non-Newtonian behavior, nozzle clogging, and irregularities in the printed fibers

**Conclusion/Action Items:**

- There is still work to be done with bioprinting vasculature

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 8:12 PM CST



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**Multimaterial_chaotic_printing_of_reinforced_and_prevascularized_hydrogel_filaments.pdf (5.43 MB)**

# 2025/12/15 - Potential Diagnostic applications of Bioprinting

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 15, 2025, 8:27 PM CST

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Find applications of bioprinting bone tissue

**Search term:** Bioprinting bone tissue

**Citation:** L. Marini et al., “Possible Diagnostic and Therapeutic Applications of Bioprinting for Bone Regeneration in Maxillofacial Surgery,” Diagnostics, vol. 15, no. 23, p. 2978, Nov. 2025, doi: https://doi.org/10.3390/diagnostics15232978.

**Link:** https://pmc.ncbi.nlm.nih.gov/articles/PMC12691056/

**Content:**

- Recent review article examining 3D bioprinting tech in bone regeneration, specifically analyzing tech constraints in vascularization
- Includes primer on bone regeneration, challenges of vascularization of bioprinted bone constructs
- Bone regeneration
    - Inflammation begins the healing immediately after injury when a hematoma triggers immune response of neutrophil & macrophage cells releasing cytokines, pro-inflammatory mediators & growth factors
    - temporary scaffold of cartilaginous matrix forms when fibroblasts & mesenchymal stem cells (MSCs) migrate to the damaged site & differentiate into chondrocytes
    - New bone gradually replaces the temporary matrix via endochondral ossification when osteoblasts derived from MSCs deposit bone matrix
    - Osteoclasts resorb immature bone while osteoblasts synthesize & mineralize mature lamellar bone, restoring the original microarchitecture & mechanical
    - Bone regeneration is governed by signaling pathways & growth factors - bone morphogenetic proteins, parathyroid hormone, Wnt/beta-catenin pathway, notch signaling
- Vascularization of bioprinted bone constructs
    - Crucial to tissue survival & integration because bring oxygen and nutrients, remove catabolic waste, and allow access of immune system cells for defense
    - Requires resolution of bioprinters sufficient to reproduce capillary size vessels
    - Endothelial cells are crucial - growth factors, endothelium serves as selective barrier, instability of growth factors, difficulty using synthetic markers to fabricate small, porous vessels

**Conclusion/Action Items:**

- Significant progress in vascularization of bone contructs
- Challenges
    - integrating vascular networks with osteogenic components
    - Further advances in printing resolution & functional tissue integration required before clinical translation

*Review*

# Possible Diagnostic and Therapeutic Applications of Bioprinting for Bone Regeneration in Maxillofacial Surgery

Lorenzo Marini [1,†], Alessandro Tel [1,*†], Marco Zeppieri [2,3,*†], Luca Michelutti [1], Massimo Robiony [1], Caterina Gagliano [4,5], Fabiana D'Esposito [4,5], Matteo Capobianco [7,8], Tamara Ius [9,10] and Marieme Khouyyi [10,†]

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† These authors contributed equally to this work, and they share the first co-authorship.
‡ These authors contributed equally to this work, and they share the last co-authorship.

**Abstract**

**Background:** The integration of 3D bioprinting, biomaterials science, and cellular biology presents a viable strategy for maxillofacial bone regeneration, overcoming the constraints of traditional graft techniques. This review offers a thorough examination of the present condition, obstacles, uses, and future outlook of 3D bioprinting technology in craniofacial bone regeneration. An essential understanding has been attained by analyzing the technological constraints, specifically in vascularization and tissue integration, and by delineating the vital translational pathway from benchtop models to clinical application. We have examined several bioprinting techniques—namely extrusion, inkjet, and laser-assisted methods—and the requisite bioinks, emphasizing their physicochemical and biological features vital for osteogenesis. Significant clinical applications, including the treatment of trauma-induced abnormalities and the reconstruction of oncology-related resections, have been emphasized. This review highlights the urgent necessity for established regulatory frameworks and refined printing settings to guarantee effective, functional, and durable bone substitutes, providing a distinct pathway for future research and clinical implementation in this specialized surgical domain. **Aim:** The purpose of this review was to present a general overview of the current clinical and diagnostic applications of bioprinting in bone tissue engineering for the reconstruction of bone defects. **Methods:** A search of major scientific databases, including PubMed, Science Direct, Embase, and Cochrane, was conducted. Articles published within the last 10 years that analyze the possible applications of bioprinting in bone tissue fabrication were included. **Results:** Several bioinks, based on hydrogels and stem cells, can enable the fabrication of such tissues using this technology. This review reports on the processes adopted for the bioprinting of bone tissue, the bioinks used, and cell cultivation methods. **Conclusions:** Bioprinting represents a promising solution for bone regeneration with potential applications that could revolutionize current surgical practices, despite the many challenges that future research will face.

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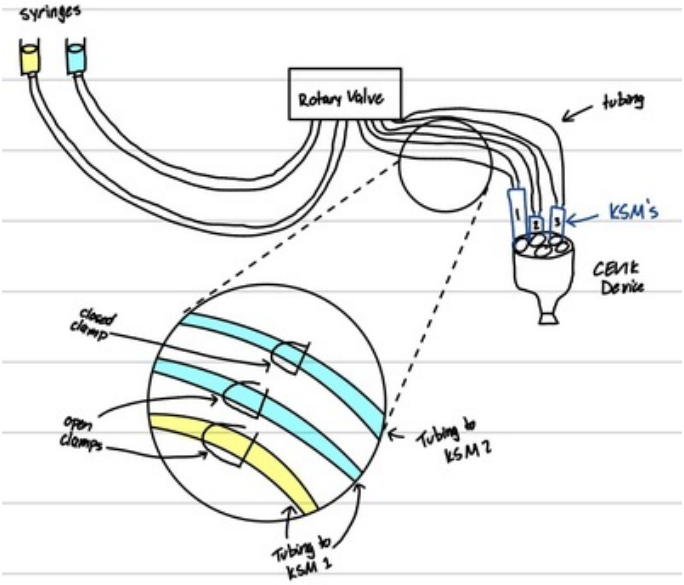
# Clamp Design Initial Idea

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 26, 2025, 1:50 PM CDT

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**IMG_4553.jpg (139 kB)**

# CEVIC Solidpart design process

ANA CLARA TOSCANO - Nov 19, 2025, 3:30 PM CST

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**Newest_CEVIC.sldprt (55.8 kB)** Credit to Jesse in Teamlab for helping create this part.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 31, 2025, 10:23 AM CDT

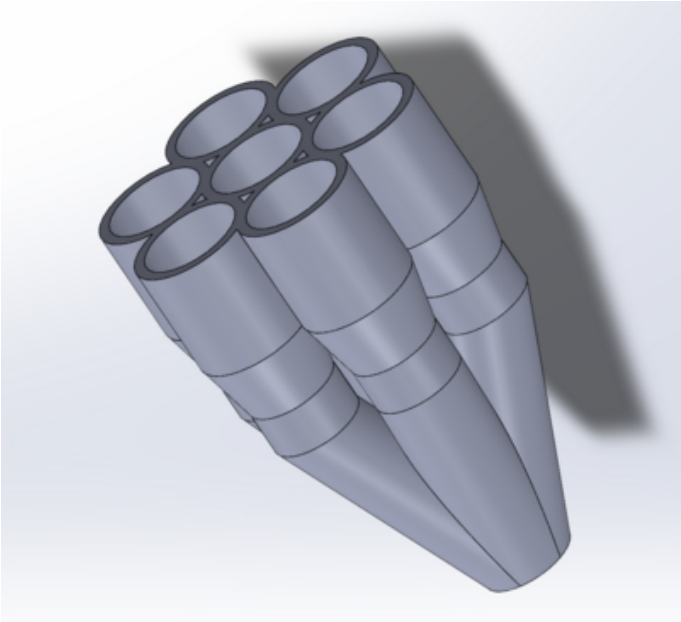
I ended up meeting with Jesse in the Makerspace for a consult because I was having trouble modeling the part. While there, he walked me through how he was thinking about modeling the CEVIC and troubleshooting different things. He shared the part with me in Onshape, and I exported as a Solidpart we can use to work on our design.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 22, 2025, 2:18 PM CDT

Content by: Steph

- Started working on the model 18 Oct. 2025 - current approach is to model one part, then circular pattern for the 6 around, then model the inside part
  - Got a bit stuck on how to do the angle extrusions for the bottom part
  - Also difficult because we do not have too many measurements, so a lot of guessing while using a ruler and best judgement
- 21 Oct. 2025 - went to ULC tutoring for Solidworks help
  - Managed to get the extrusions by lofting one face to the next, and circular patterning
  - Still stuck on how to make it gradual curve - chamfer?
  - Also the fan bit seems tricky

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 22, 2025, 2:21 PM CDT



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**Cevic_as_of_21_Oct..png (360 kB)** Cevic as of 21 Oct. 2025

# October 26 Servo Testing

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 3:07 PM CDT

**Date:** 26 October 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Test Servo with some Arduino code

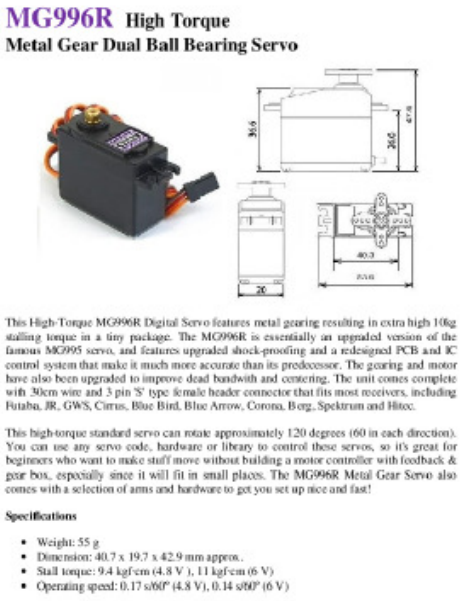
**Content:**

- Wanted to test Servo motor as proof of concept and subsequently design something for IRE
- Looked up PIN diagram for where to put wires
- Built a circuit inspired by BME 310 circuits
    - Button in the middle to trigger motor to turn 60 degrees, once it hits 180 degrees reverse direction so the motor does not overturn
    - Used ChatGPT to help write code (since this is mainly testing motor works and the more mechanical part of design) - code will be changed for anything we actually use
- Arduino can provide more consistent power when plugged into outlet rather than computer - servo seems to require a fair amount of water

**Conclusion/Action Items:**

- Continue to test arduino & motor
- Model part that can fit with Sophie's IRE part to connect to motor

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 3:24 PM CDT



**MG996R** High Torque
**Metal Gear Dual Ball Bearing Servo**

This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. The MG996R is essentially an upgraded version of the famous MG995 servo, and features upgraded shock-proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwith and centering. The unit comes complete with 30cm wire and 3 pin 'S' type female header connector that fits most receivers, including Futaba, JR, GWS, Cirrus, Blue Bird, Blue Arrow, Corona, Berg, Spektrum and Hitec.

This high-torque standard servo can rotate approximately 120 degrees (60 in each direction). You can use any servo code, hardware or library to control these servos, so it's great for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. The MG996R Metal Gear Servo also comes with a selection of arms and hardware to get you set up nice and fast!

**Specifications**

- Weight: 55 g
- Dimension: 40.7 x 19.7 x 42.9 mm approx.
- Stall torque: 9.4 kgf·cm (4.8 V ), 11 kgf·cm (6 V)
- Operating speed: 0.17 s/60° (4.8 V), 0.14 s/60° (6 V )

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**mg996r_servo.pdf (95.9 kB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 3:08 PM CDT

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**IMG_8435.MOV (28 MB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 3:15 PM CDT

**Code (caution: from ChatGPT and we need to create our own code):**

```
#include <Servo.h>  // or #include <ServoR4.h> if using UNO R4


Servo myServo;


const int buttonPin = 2;

const int servoPin = 9;


int lastButtonState = HIGH;

int angle = 0;

int step = 60;  // move by 60° each press
```

```
void setup() {
  myServo.attach(servoPin);
  pinMode(buttonPin, INPUT_PULLUP);
  myServo.write(angle);
}

void loop() {
  int currentState = digitalRead(buttonPin);

  // Detect button press (HIGH → LOW transition)
  if (lastButtonState == HIGH && currentState == LOW) {

    // Move by 60° in the current direction
    angle += step;

    // Reverse direction at limits
    if (angle >= 180) {
      angle = 180;   // stay in range
      step = -60;    // reverse direction
    }
    else if (angle <= 0) {
      angle = 0;
      step = 60;     // reverse direction again
    }

    myServo.write(angle);
    delay(300);  // debounce
  }
```

```
    lastButtonState = currentState;
  }
```

# October 26 Gear design

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 4:43 PM CDT

**Date:** 26 October 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Model a gear for testing

**Content:**

- Since I made sure the servo motor functions, now I want to create a gear that fits on it and connects to the part Sophie designed
- Central diameter: about 0.230 inches = 5.842 mm; 25 teeth
  - 5.84 mm --> 2.92 mm radius --> circumference = 18.347 mm
- Sophie's part: 27 mm in diameter; 80 teeth
  - 27 mm --> radius = 13.5 mm --> circumference = 84.823 mm
- Went to Onshape because was having trouble with gear
  - 1.06 in diameter outer circle, 25 teeth
  - Remodeled IRE part to try to make gears fit
  - Onshape allowed me to import a gear and make modifications - was easier than what I was trying in Solidworks

**Conclusion/Action Items:**

- Will try to 3D print the parts at Makerspace Monday
- Not sure if gear teeth will fit together, so may have to change based on that
- Still have to figure out how to connect part securely to the motor

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 4:41 PM CDT

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**New_IRE_part_-_Spur_gear_25_teeth_.stl (135 kB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 26, 2025, 4:41 PM CDT

Download

**Servo_Gear_-_Spur_gear_25_teeth_.stl (112 kB)**

# December 2 Circuit diagram

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:46 PM CST

**Date:** 2 December 2025

**Content by:** Steph Vigmond

**Present:** N/A

**Goals:** Create a circuit diagram for the poster

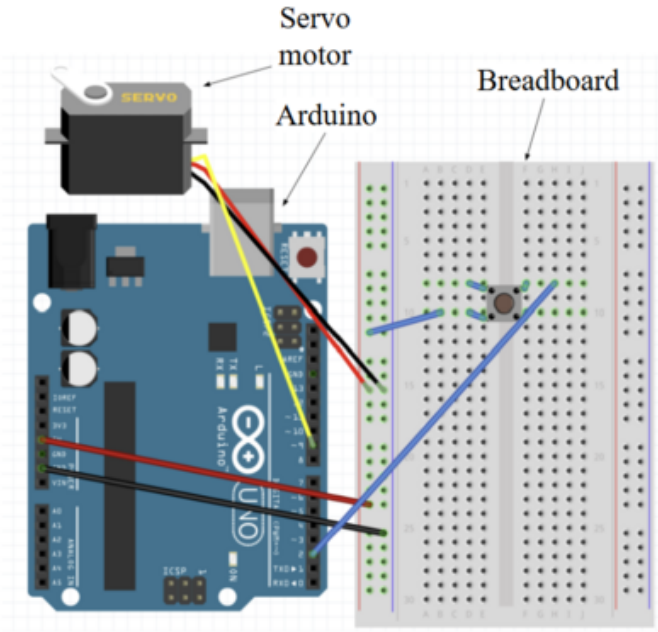
**Content:**

Please see attached diagram

**Conclusion/Action Items:**

- Add onto poster, look into circuit diagram that can show Servo and Arduino

STEPHANIE VIGMOND (vigmond@wisc.edu) - Dec 13, 2025, 9:46 PM CST

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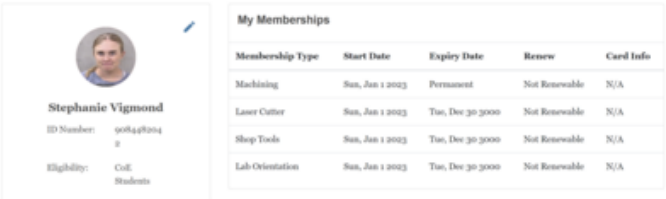
**circuit_full.png (234 kB)**

# Machine Shop Training

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 18, 2024, 7:57 PM CST

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**Green_Pass.png (277 kB)**

# Biosafety & Chem Safety Training

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 08, 2024, 7:16 PM CDT

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

This certifies that Stephanie Vigmond has completed training for the following course(s):

| Course | Assignment | Completion | Expiration |
|---|---|---|---|
| Biosafety Required Training | Biosafety Required Training Quiz 2024 | 2/14/2024 | 2/14/2029 |
| Chemical Safety: The OSHA Lab Standard | Final Quiz | 1/19/2024 | |

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**Biosafety_Chemical_Safety_Training.png (162 kB)**

# Woodshop Training

STEPHANIE VIGMOND (vigmond@wisc.edu) - Oct 28, 2024, 6:07 PM CDT

| Membership Type | Start Date | Expiry Date | Renew | Card Info |
|---|---|---|---|---|
| Woodshop Orientation | Mon, Oct 14 2024 | Permanent | Not Renewable | N/A |

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**Woodshop_Permit.png (39.1 kB)**

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 07, 2025, 9:45 AM CDT

Stephanie Vigmond

ID Number: 90644820 42

Eligibility: CoE Students

My Memberships

| Membership Type | Start Date | Expiry Date | Renew | Card Info |
|---|---|---|---|---|
| Woodshop Orientation | Mon, Oct 14 2024 | Permanent | Not Renewable | N/A |
| Machining | Sun, Jan 1 2023 | Permanent | Not Renewable | N/A |
| Laser Cutter | Sun, Jan 1 2023 | Tue, Dec 30 3000 | Not Renewable | N/A |
| Shop Tools | Sun, Jan 1 2023 | Tue, Dec 30 3000 | Not Renewable | N/A |
| Lab Orientation | Sun, Jan 1 2023 | Tue, Dec 30 3000 | Not Renewable | N/A |

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**Design_Innovation_Lab_Trainings.png (283 kB)**

# Centrifuge Safety

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 07, 2025, 11:25 AM CDT

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UNIVERSITY OF WISCONSIN-MADISON

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| Course | Assignment | Completion | Expiration |
|---|---|---|---|
| Biosafety 107: Centrifuge Safety | Biosafety 107: Centrifuge Safety Verification Quiz | 9/7/2025 | No Expiration |
| Biosafety Required Training | Biosafety Required Training Quiz 2024 | 2/14/2024 | 2/14/2029 |
| Chemical Safety: The OSHA Lab Standard | Final Quiz | 1/19/2024 | |

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**Biosafety_training.png (181 kB)**

# Human Subjects Training

STEPHANIE VIGMOND (vigmond@wisc.edu) - Sep 07, 2025, 3:55 PM CDT

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Stephanie Vigmond has completed training for the following course(s):

| Course | Assignment | Completion | Expiration |
|---|---|---|---|
| Biosafety 107: Centrifuge Safety | Biosafety 107: Centrifuge Safety Verification Quiz | 9/7/2025 | No Expiration |
| Biosafety Required Training | Biosafety Required Training Quiz 2024 | 2/14/2024 | 2/14/2029 |
| Chemical Safety: The OSHA Lab Standard | Final Quiz | 1/19/2024 | |
| UW Human Subjects Protections Course | Basic/Refresher Course - Human Subjects Research | 9/7/2025 | 9/7/2028 |

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**Human_subjects.png (212 kB)**

# 2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

**Title:** Descriptive title (i.e. Client Meeting)

**Date:** 9/5/2016

**Content by:** The one person who wrote the content

**Present:** Names of those present if more than just you (not necessary for individual work)

**Goals:** Establish clear goals for all text entries (meetings, individual work, etc.).

**Content:**

Contains clear and organized notes (also includes any references used)

**Conclusions/action items:**

Recap only the most significant findings and/or action items resulting from the entry.

# 2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

**Title:**

**Date:**

**Content by:**

**Present:**

**Goals:**

**Content:**

**Conclusions/action items:**