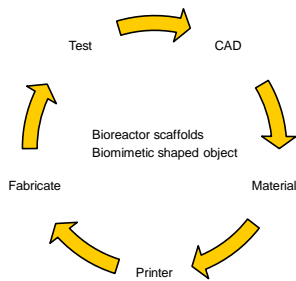# The 3D Printing Process: How Do I *Actually* Make This?

Max J. Lerman

Department of Materials Science and Engineering, University of Maryland
Surface and Trace Chemical Analysis Group, National Institute of Standards and Technology
Center for Engineering Complex Tissues, University of Maryland

June 8th, 2017

Overview

Test → CAD → Material → Printer → Fabricate → Test

Bioreactor scaffolds
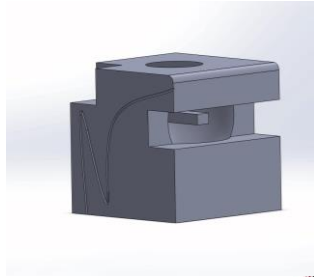Biomimetic shaped object

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When is 3D printing appropriate

- Rapid prototyping
  - Quick turn around ⟹ Hours to days
  - Small volumes ⟹ Dozens
  - Highly customizable ⟹ 'Soft' design

When is 3D printing appropriate

- Rapid prototyping
  - Quick turn around
  - Small volumes
  - Highly customizable

- Early design decisions
  - Internal features
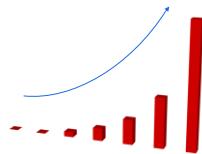 - Overhangs
  - Indents
  - Texture
  - Orientation

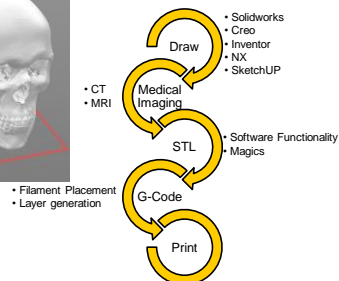## When is 3D Printing Appropriate

- Rapid prototyping
  - Quick turn around
  - Small volumes
  - Highly customizable

- Early design decisions
  - Internal features
  - Overhangs
  - Indents
  - Texture
  - Orientation

- Paper->CAD->Manufacture->Use
  - Cost
  - Time
  - Frustration

How to Make a Model

- CT
- MRI

Draw
- Solidworks
- Creo
- Inventor
- NX
- SketchUP

Medical Imaging

STL
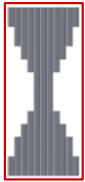- Software Functionality
- Magics

G-Code
- Filament Placement
- Layer generation
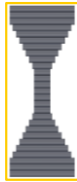
Print

Nevit Dilmen, NIH 3D Print Exchange

Printing Orientation

- Effect of orientation of print design on its properties
  - Mechanical strength
  - Structure stability
  - Print accuracy

VS.

CECT

Printer Selection

- FDM
- Powder Bed
- SLA/DLP
- SLS/SLM/EBM
- LOM (laminated)

envisionTEC.com
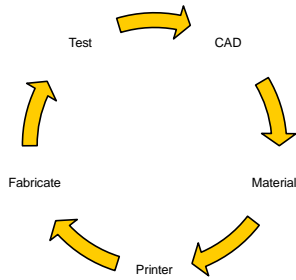
CECT

Material Selection

- Often dictated by printer selection (done in tandem)
- What is the FUNCTION of the part?
- What are the down stream applications/intended use?
  - Solubility, cleaning, cell contacting, etc.
- Cost
- Available materials
  - Ceramics
  - Metals
  - Hard Plastics
  - Soft Plastics
  - Hydrogels

imaterialise.com

CECT

Example – DLP Bioreactor

Test → CAD → Material → Printer → Fabricate → Test
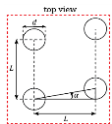
Design: Background

- Design Criteria
  - Perfusion flow
  - Non-cytotoxic
  - Compact
  - Control of shear stress
  - Clear
  - Impactful 3D geometry

- Design Utilized
  - Pillared array
  - Round – to fit inside tubing
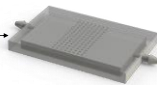 - DLP Technology – E-Shell 300

CAD Generation

top view

Imaging

Cell expansion

- Application based design
  - Single layer for imaging studies
  - Multilayered for flask replacement

Design Verification

- Computational modeling of design
- CFD informed flow, pillar array
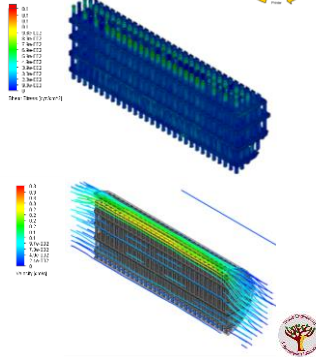
CECT

Design Improvements

- Increased volume array
- Compact structure
- Improved connections
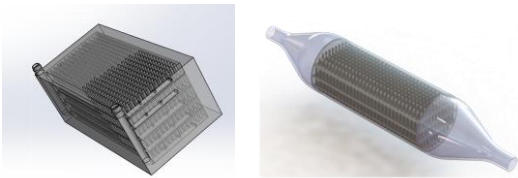
CECT

DLP Printer and Material Selection

- EnvisionTEC Perfactor 4 DLP System
  - Owned
  - Material dependent resolution (15-100 µm)
- Material options
  - All proprietary
  - Several now available
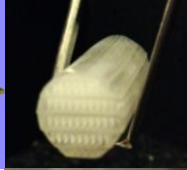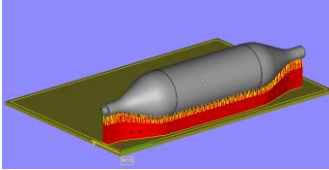 - Limited at the time to E-shell 300
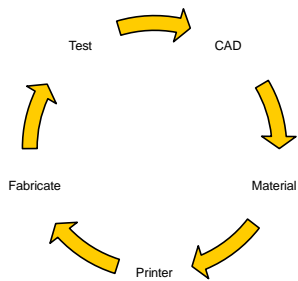

CECT

envisionTEC.com

DLP Fabrication

- Orient Parts
  - Support scaffold
  - Material outflow
  - Layer generation favorability
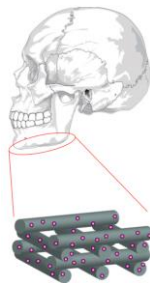- Inspect internal pillars
- Attach to bioreactor system

Example – Biomimetic Shaped Implant

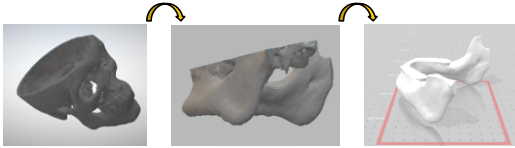Test → CAD → Material → Printer → Fabricate → Test

Background-Motivation

- Implantable craniofacial repair material
  - High structural complexity
  - Non-cytotoxic
  - Biodegradable
  - Vascularization

- Biomimetic Driven
  - CT

STL Generation

- Use CT scan from NIH 3D Print Exchange
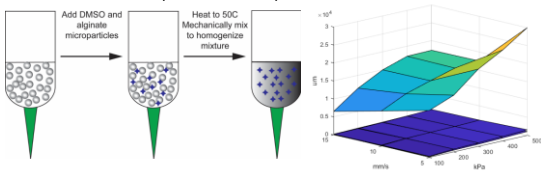- Remove excess, fragments
- Cut part down to size

Daryll Ricketts, NIH 3D Print Exchange

Biomimetic Shape – Material Tuning

- Develop new material
  - Compounding method
  - Printing method
 - Repeatability
- EnvisionTEC 3D Bioplotter available option

Add DMSO and alginate microparticles

Heat to 50C Mechanically mix to homogenize mixture

Biomimetic Shape – Print

- Process STL
  - Remove unwanted sections
  - Orient for printer

- Slice print file
  - Material properties
  - Overall shape
  - Generate G-code

- Post processing

- Test
  - Elution data
  - Yield and modulus
  - Cytotoxicity

6/18/2018
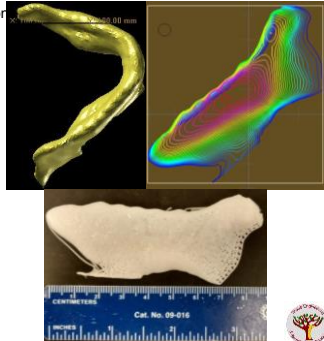
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- Justine Yu

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