



# Introduction to 3D Printing

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What's your interest in  
3D printing?

# What We Will Cover Today

1. How 3D printing works
2. 3D printing in the health sciences
3. Finding 3D models online
4. A look at our Innovation Space upstairs

**See a detailed how-to-guide at**

**<http://guides.hshsl.umaryland.edu/inspace>**

# General Points About 3D Printing

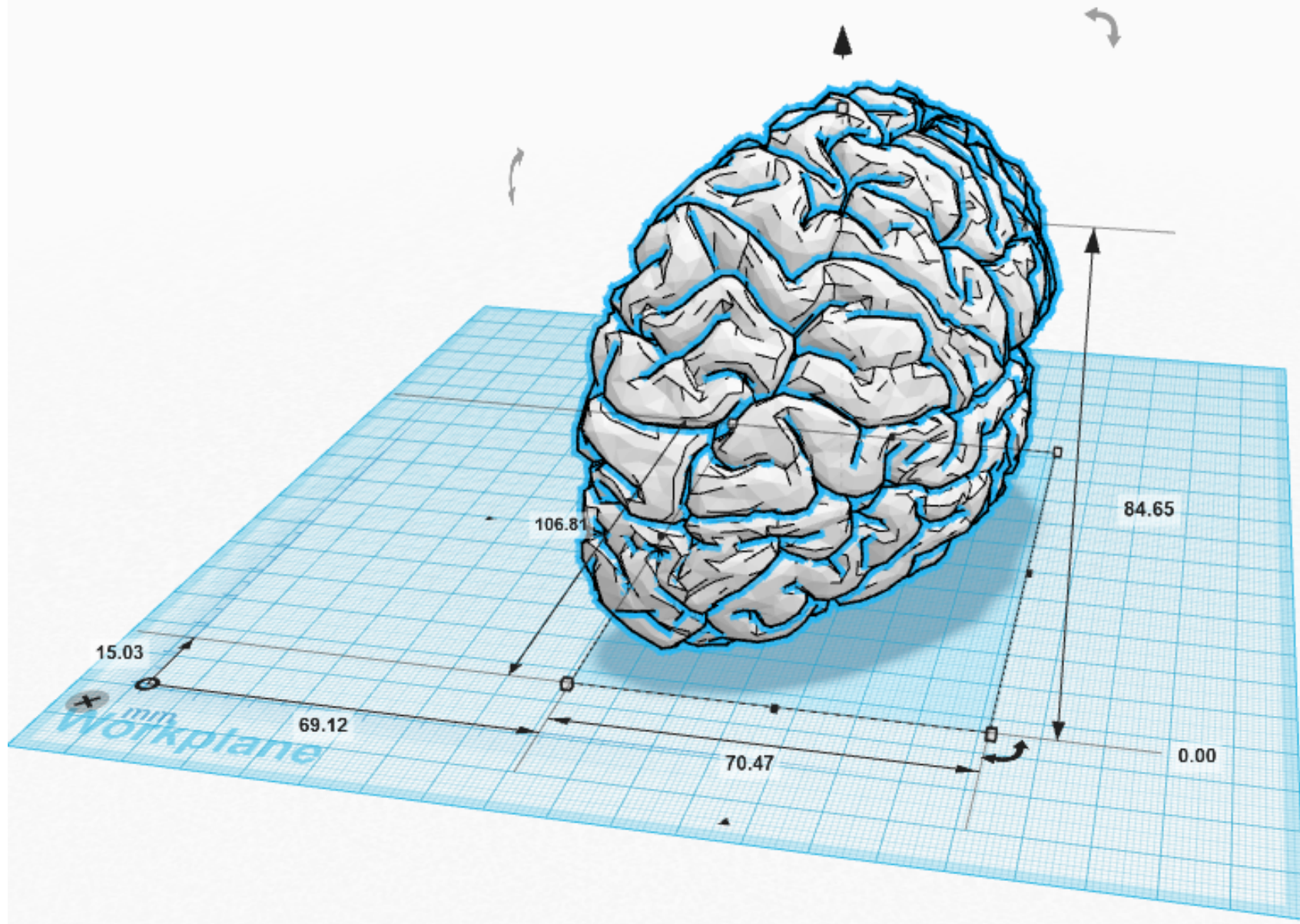
- “Additive manufacturing” is different from conventional manufacturing.
- The process starts with a 3D model.
- The object is printed layer by layer.
- Printing materials include plastics, metals, bio matter, and more.
- There are multiple printing methods.
- Consumer printers differ from industrial printers, but the process is similar.



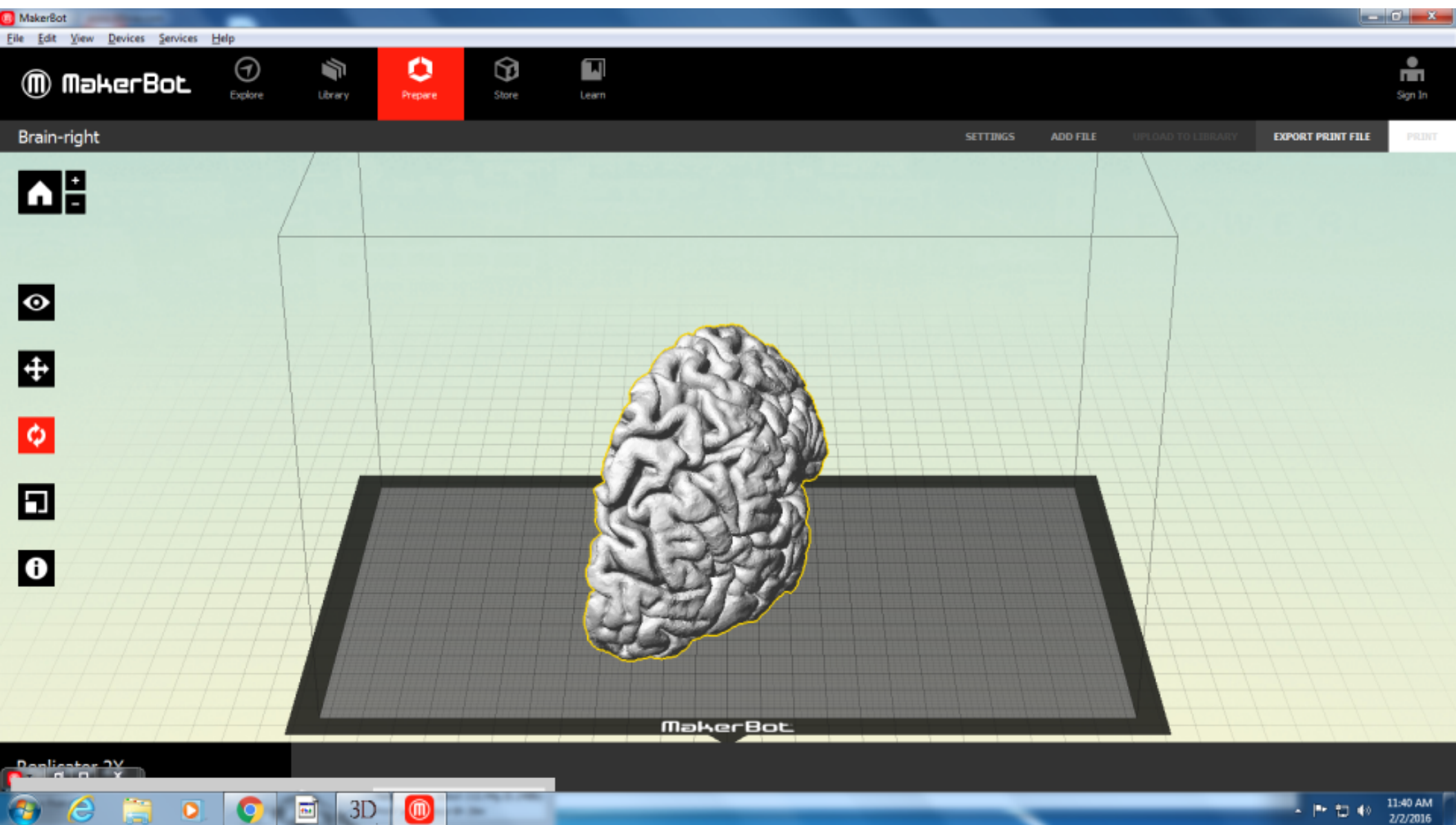
# Preparing the Model for 3D Printing

- The original 3D model gets “sliced” into many tiny layers ( $< 1\text{mm}$ ) by “slicing” software.
- The “slicing” software can also add support structures to the model for printing difficult angles ( $> 45^\circ$ ).
- Printing with supports increases material use and printing time.
- Supports need to be carefully removed when printing is complete.

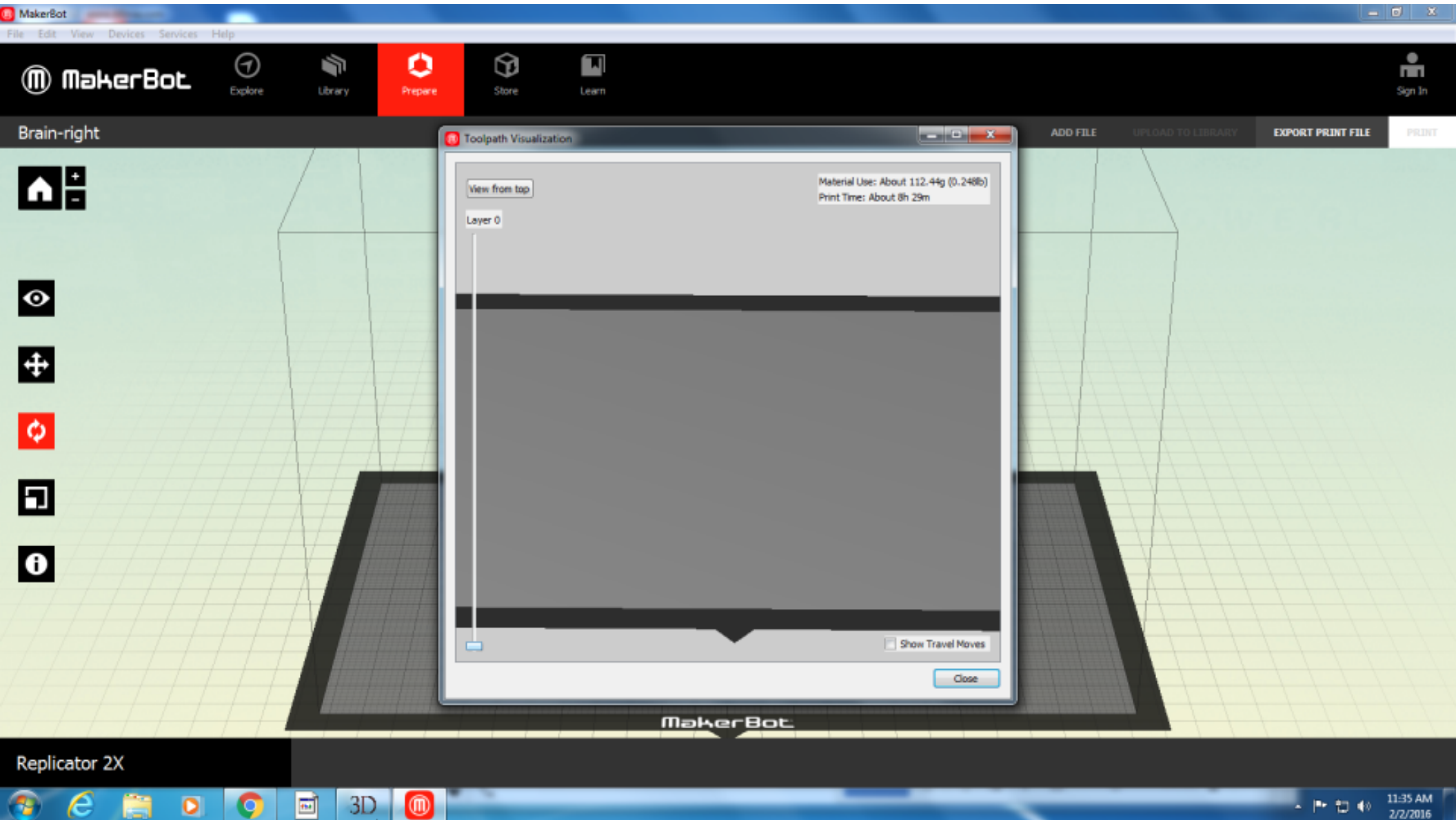
# A Model in a Design Program



# A Model in a Slicing Program

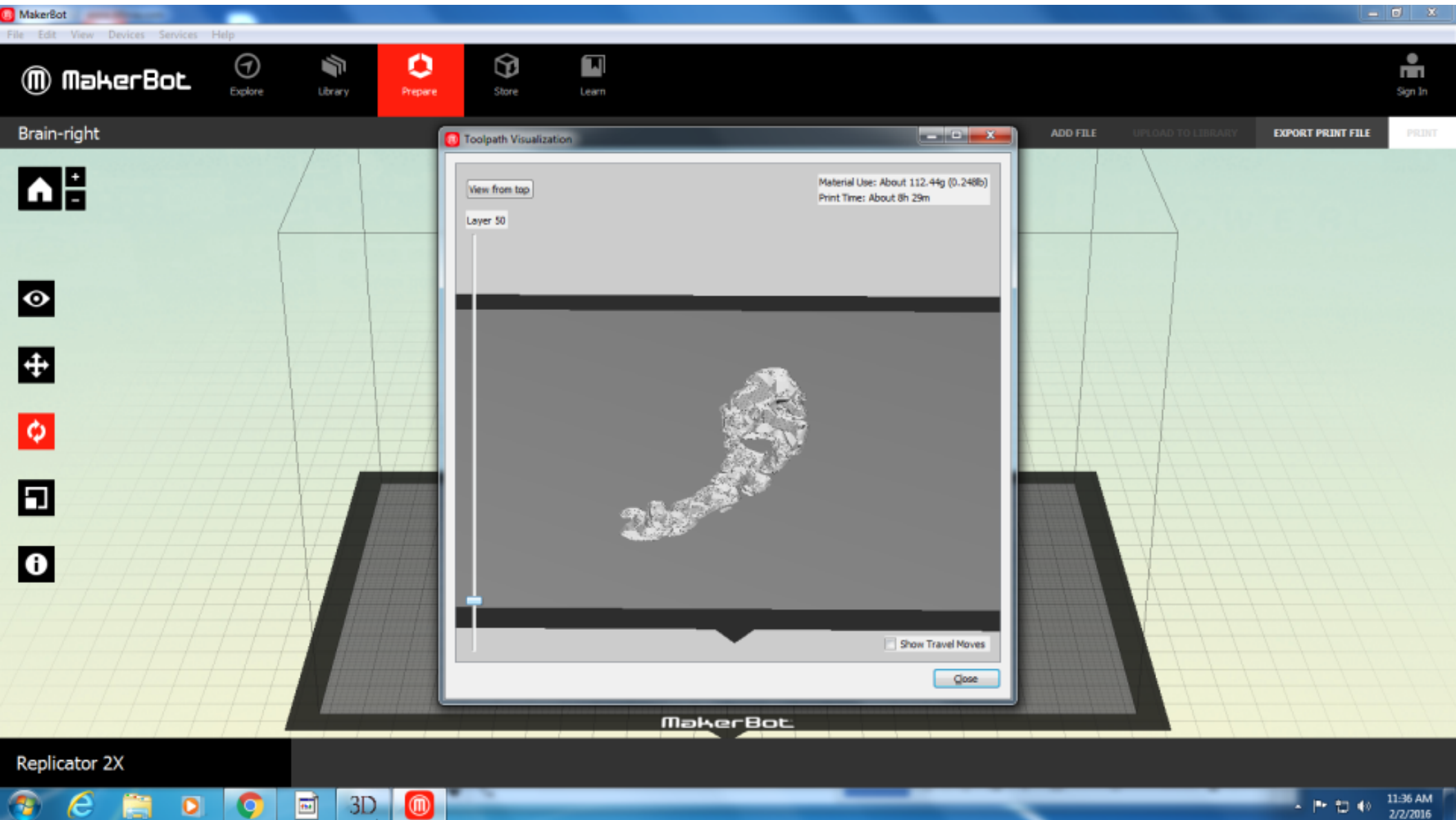


# A Preview of Layer 0

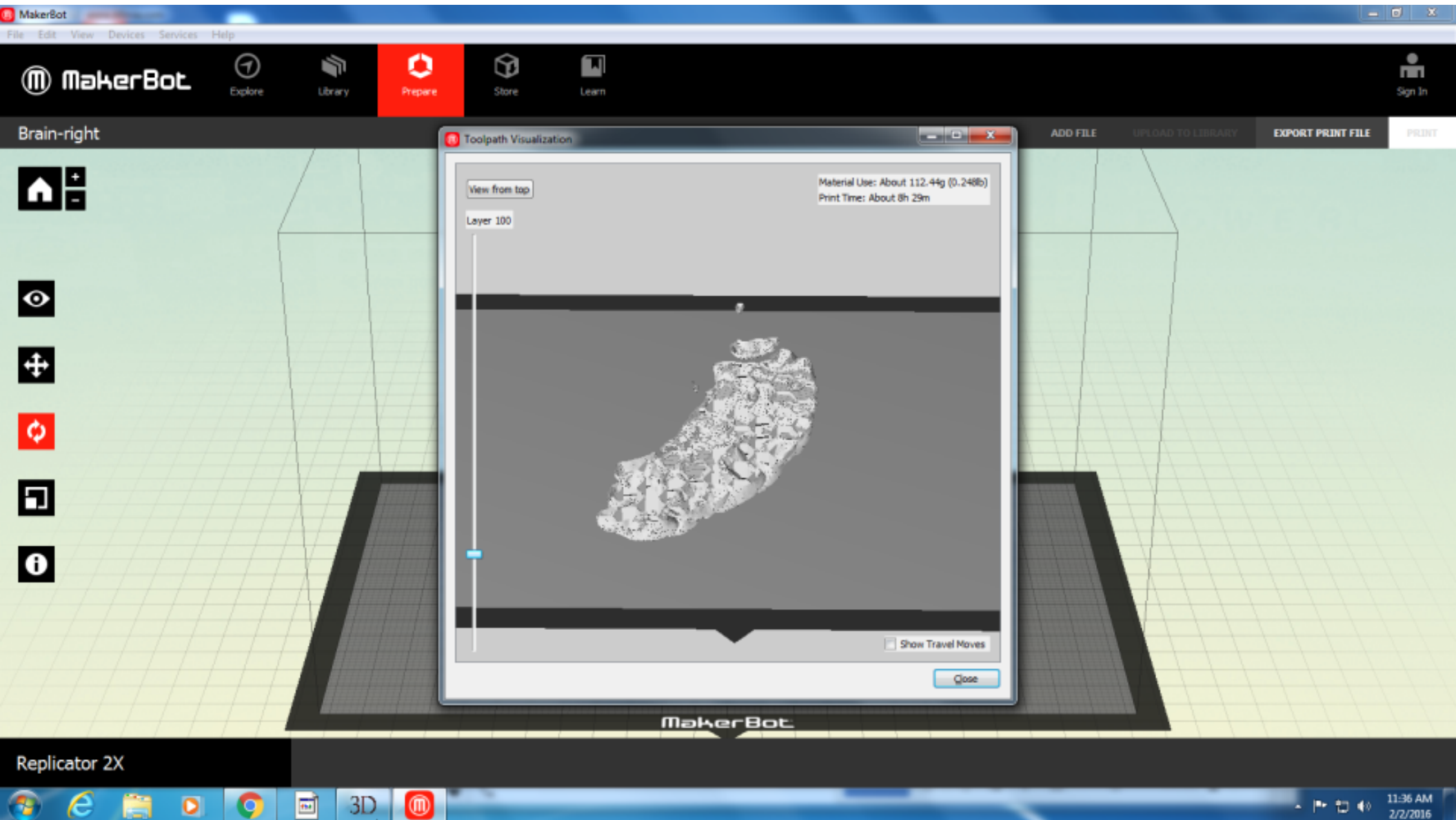




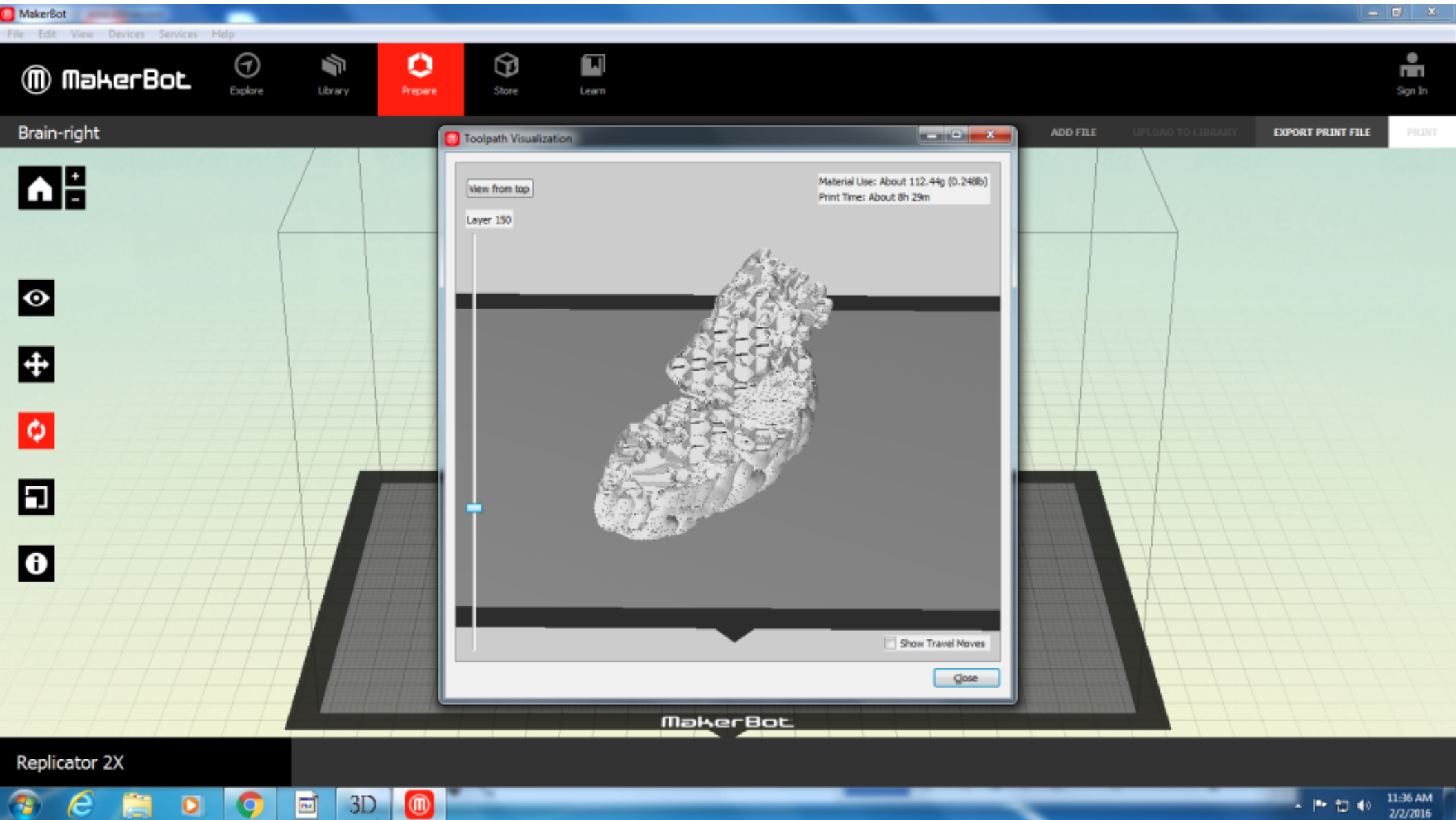
# A Preview of Layer 50



# A Preview of Layer 100

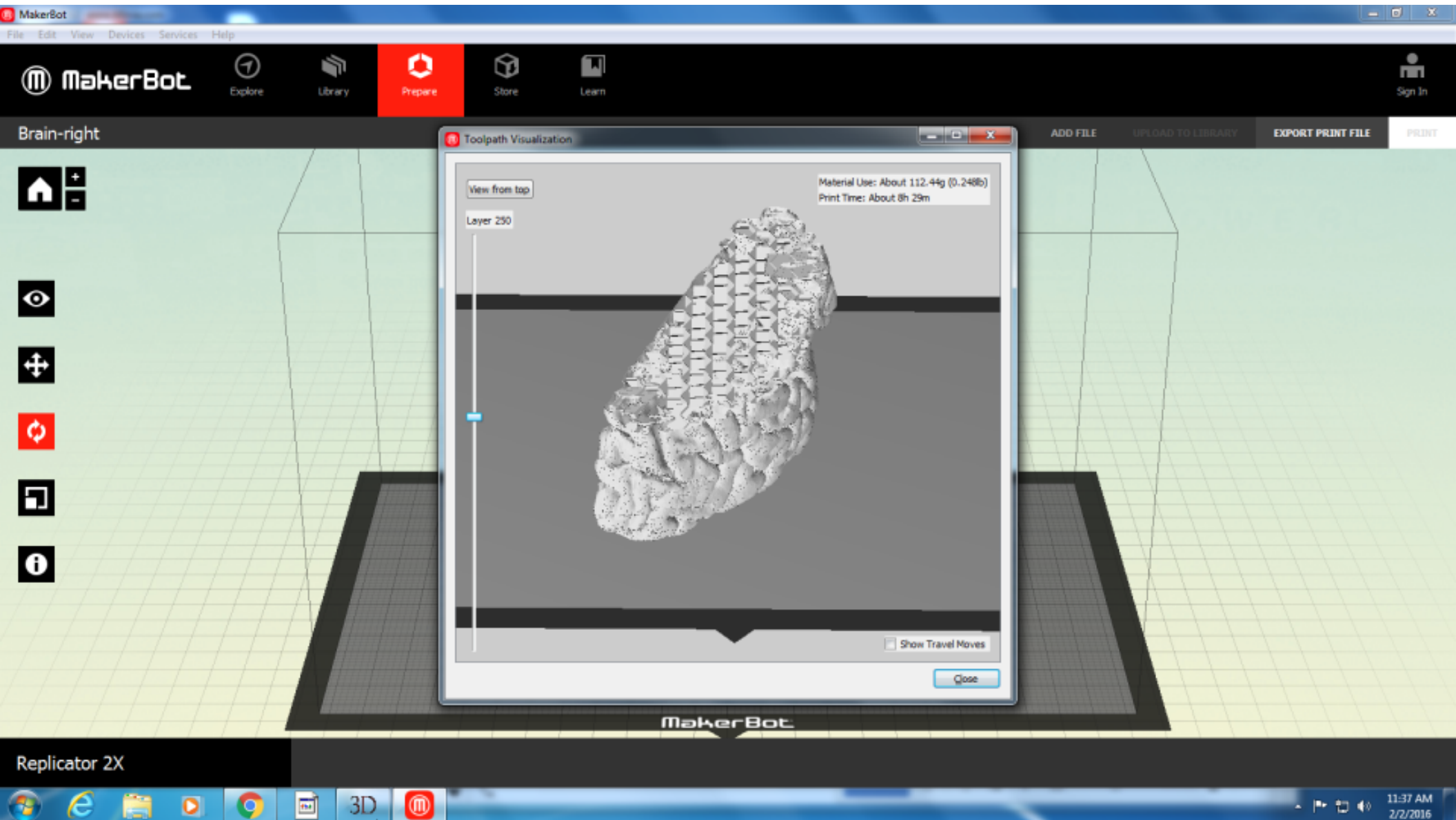


# A Preview of Layer 150

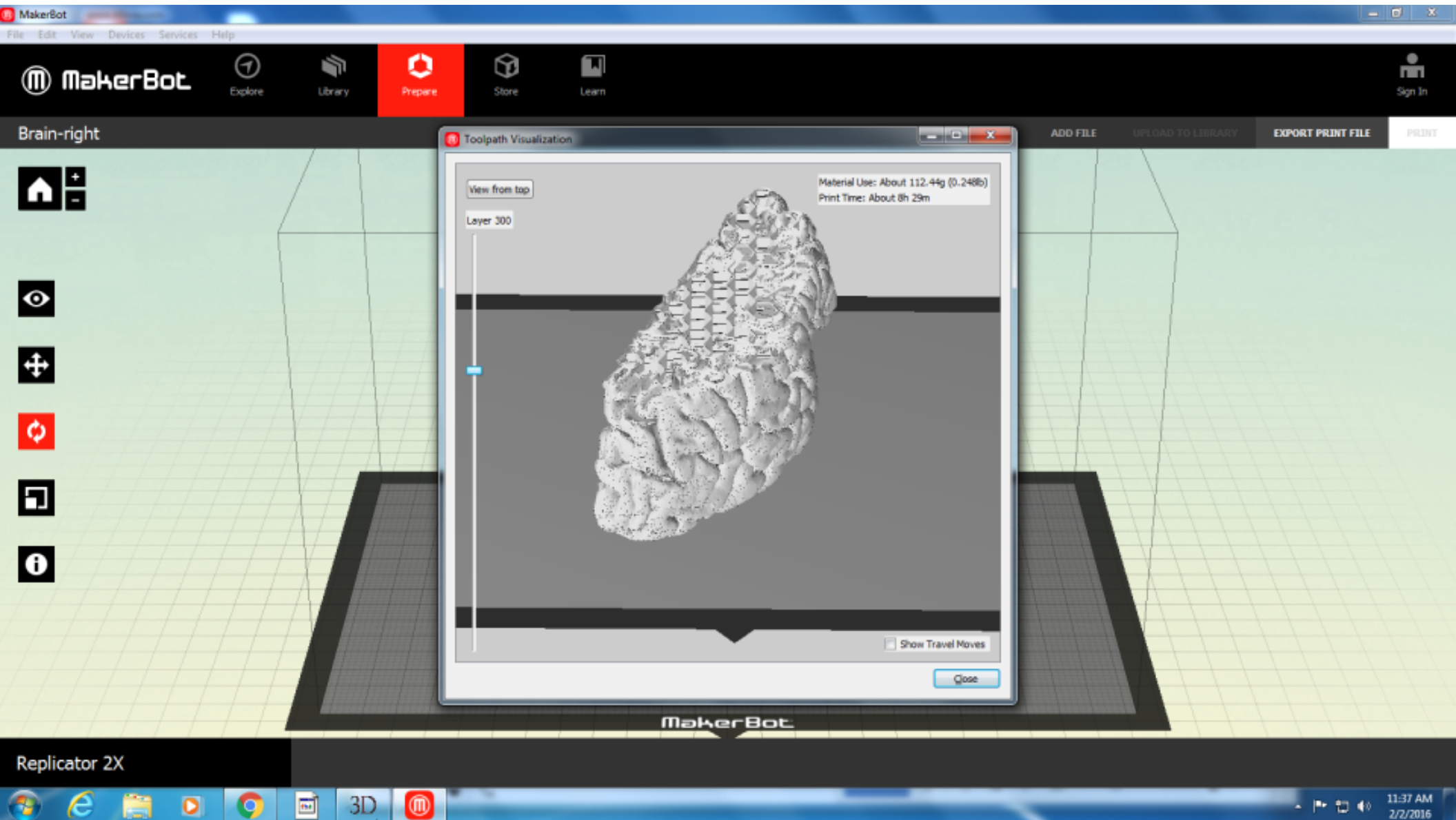




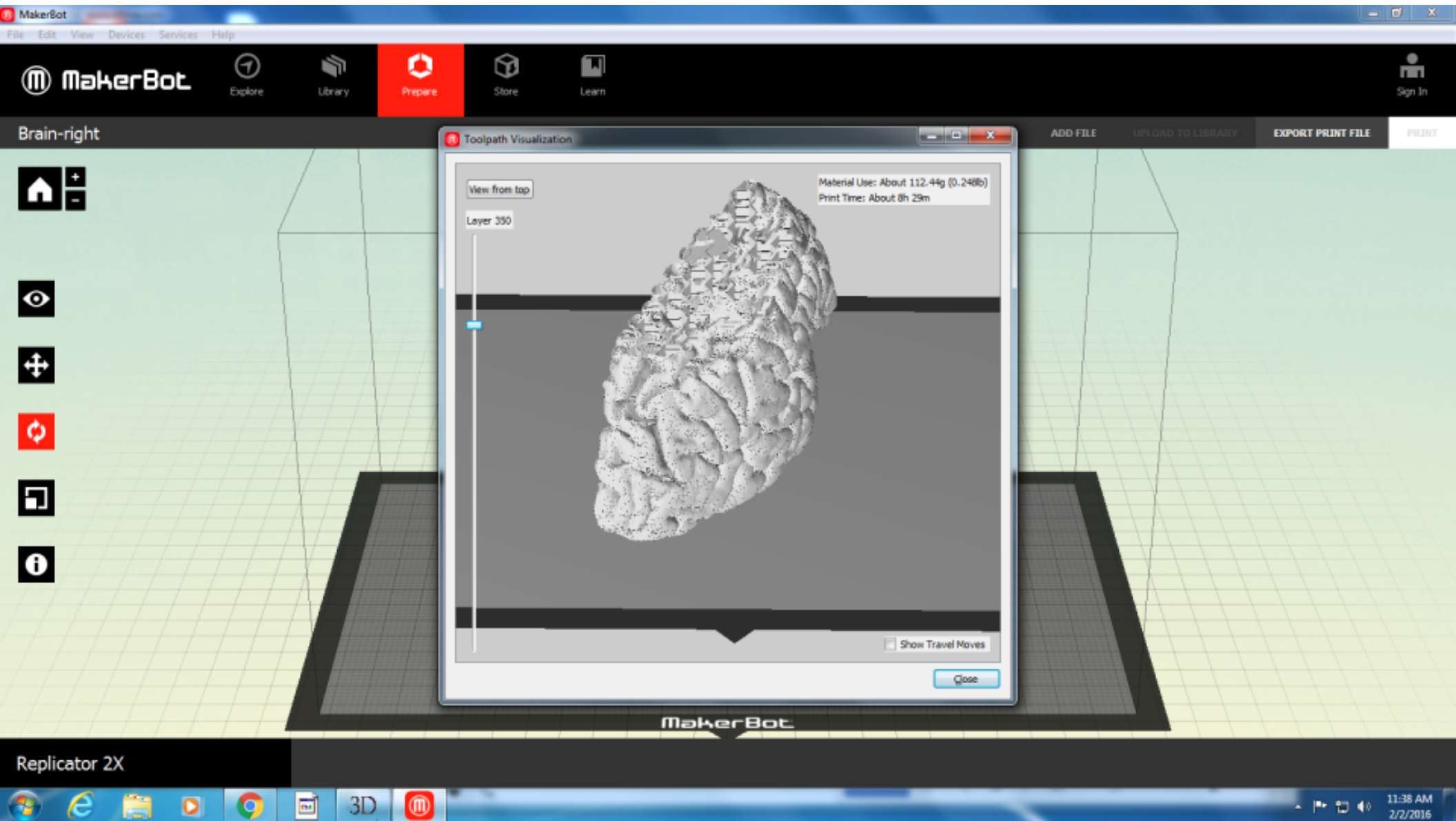
# A Preview of Layer 250



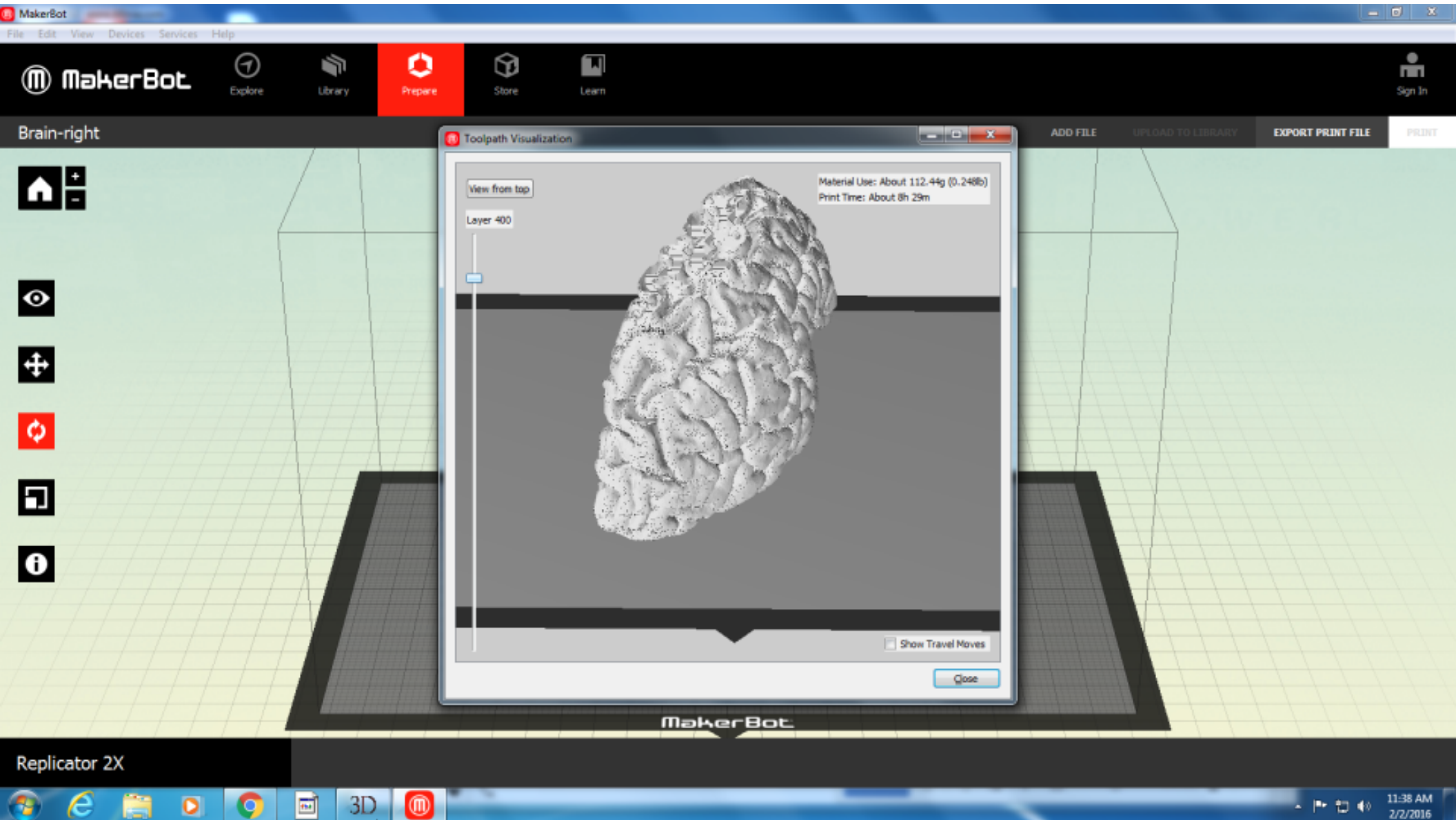
# A Preview of Layer 300



# A Preview of Layer 350

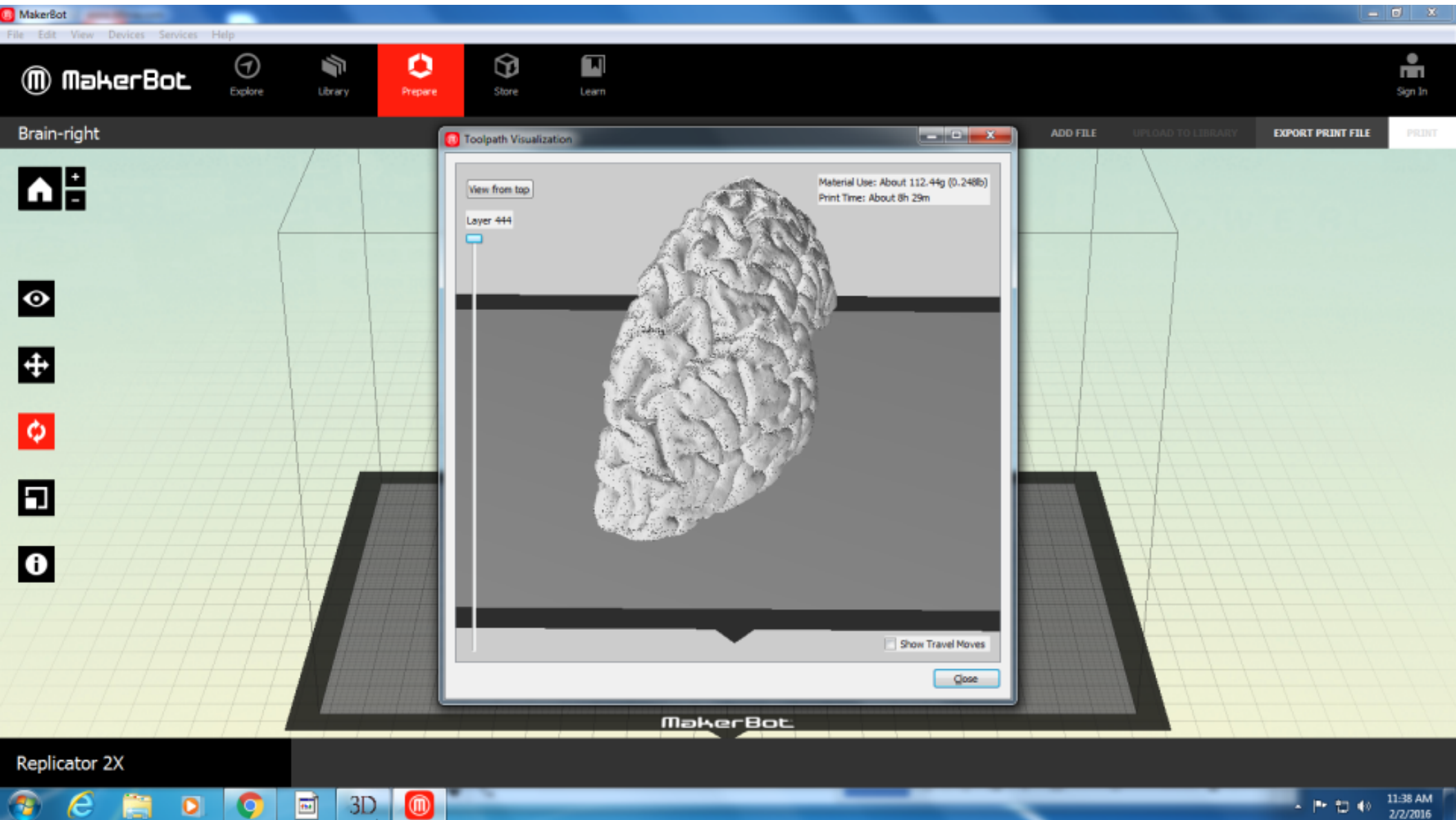


# A Preview of Layer 400

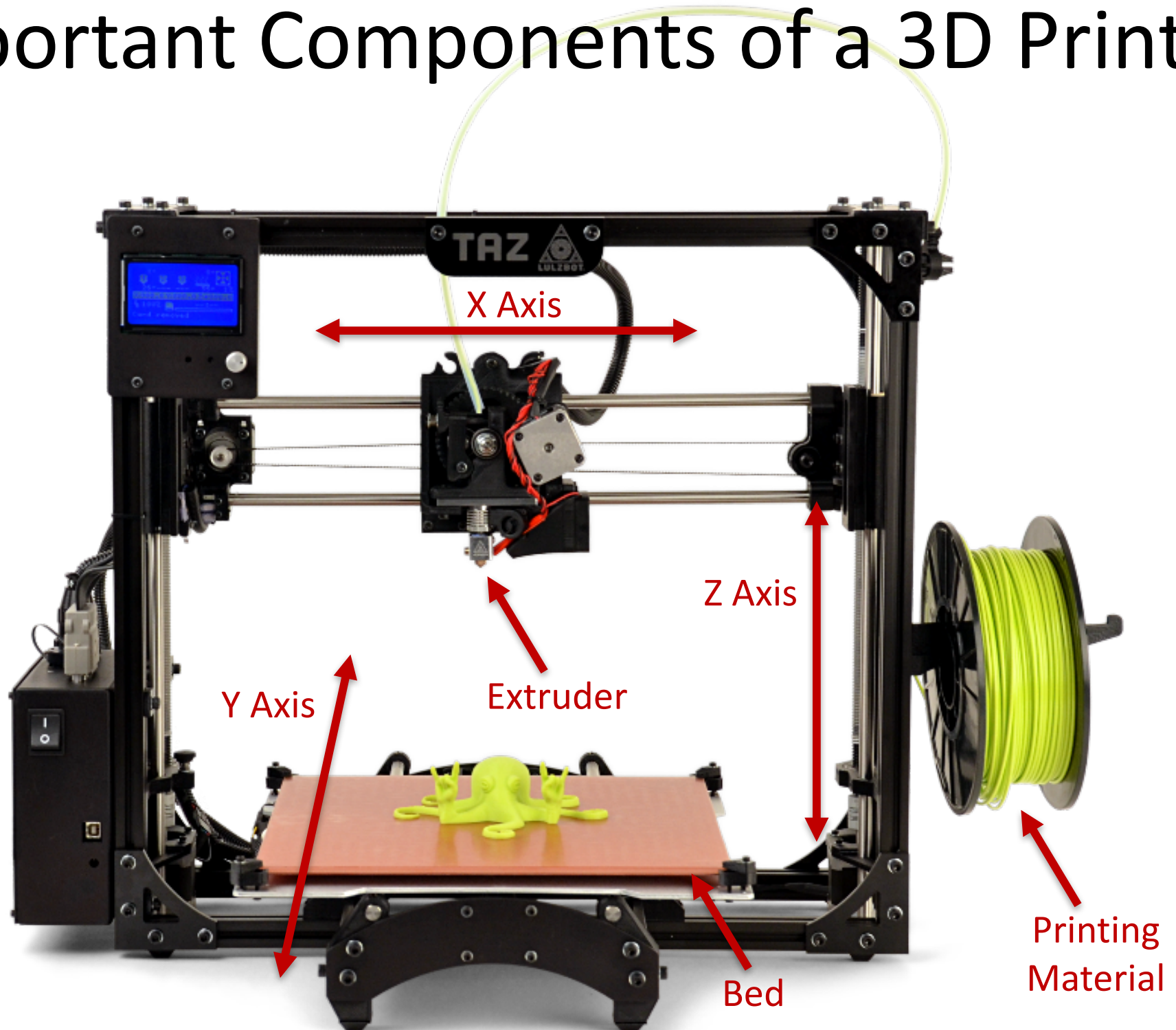




# A Preview of the Final Layer (444)



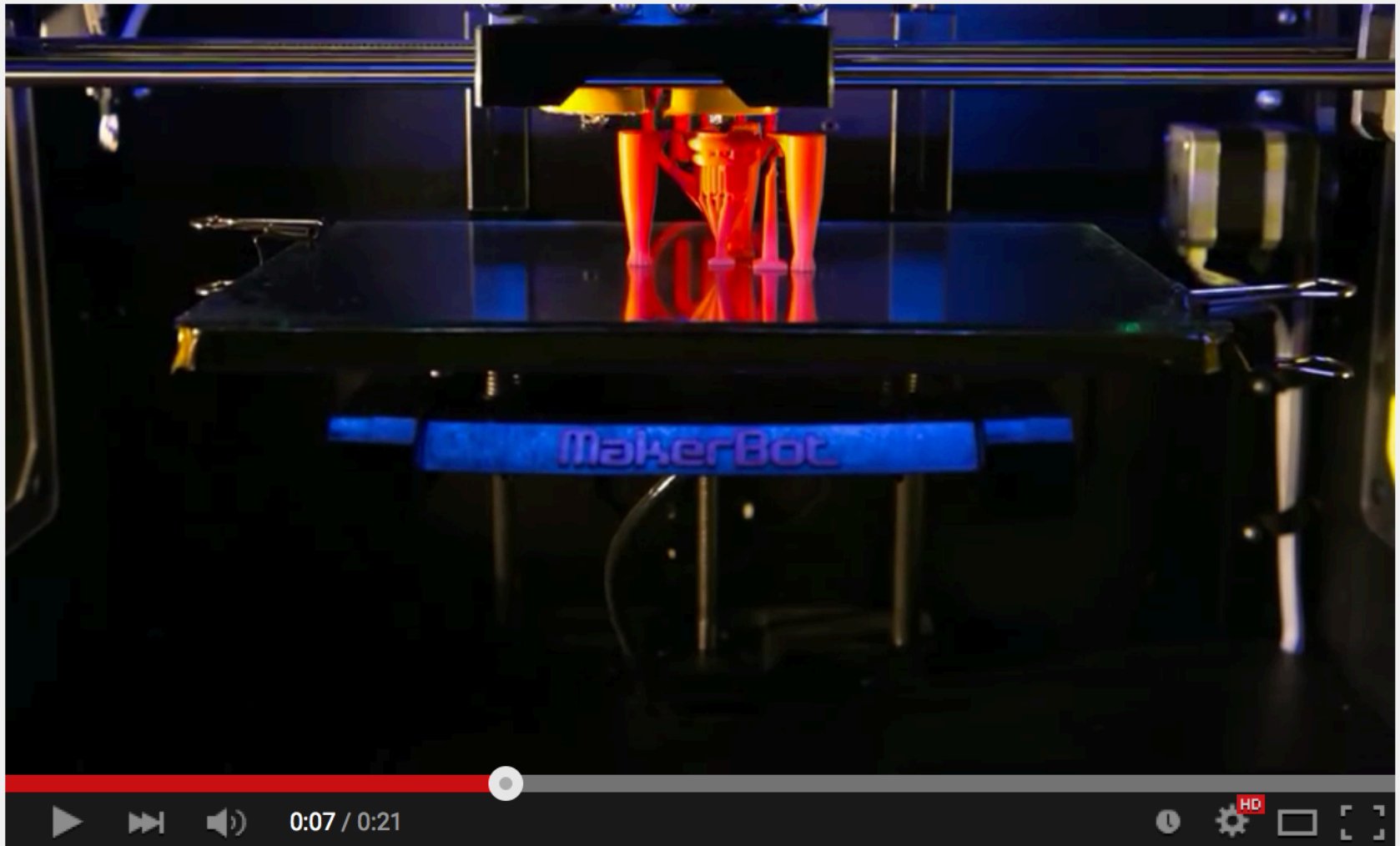
# Important Components of a 3D Printer



# Consumer 3D Printing in Action



<https://www.youtube.com/watch?v=-gaC5BpXljU>



MakerBot 3D Printing Timelapse



# Consumer 3D Printing in Action



## Introduction to Stereolithography





Formlabs

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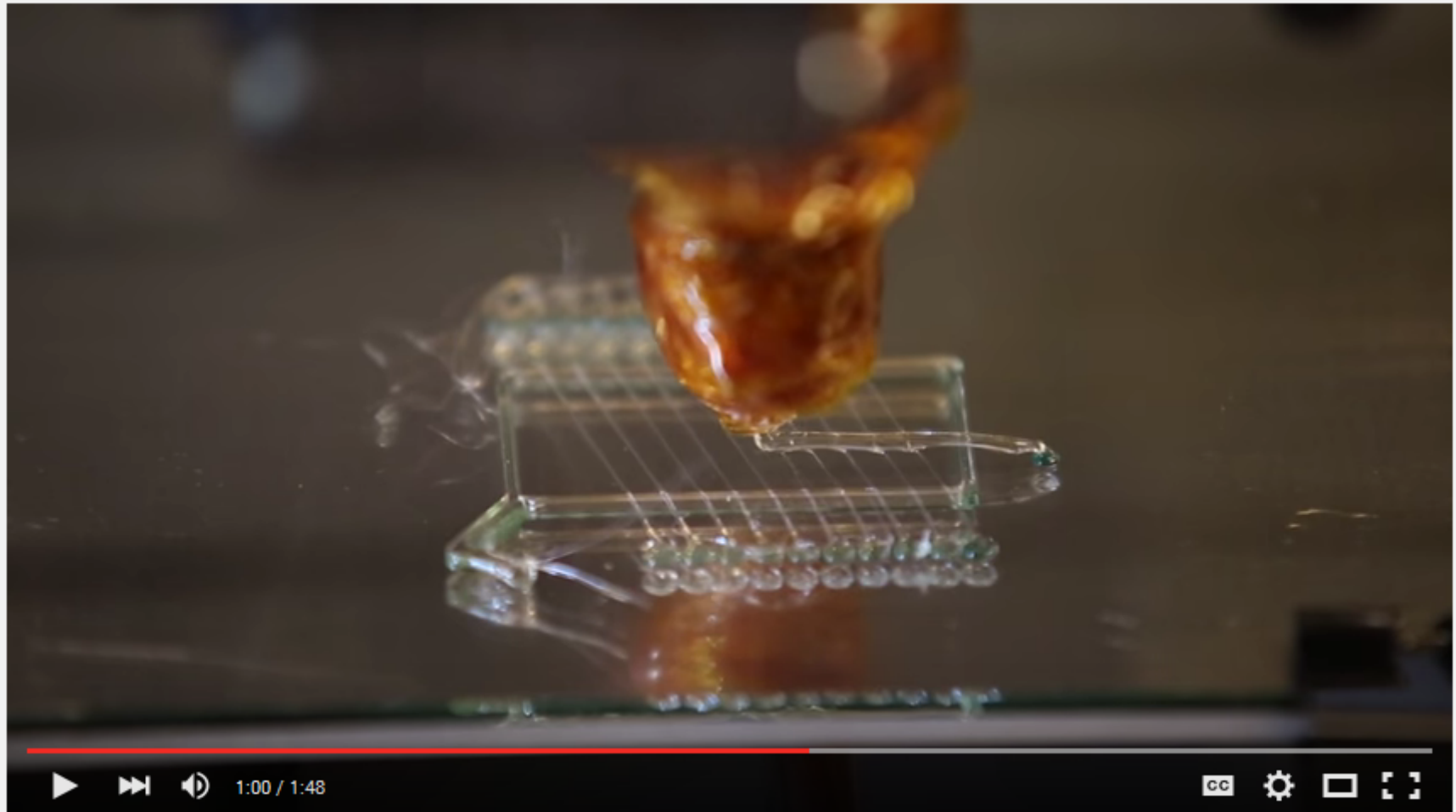
<https://youtu.be/yW4EbCWaJHE?t=16s>

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# Scientific 3D Printing in Action



## Rep Rap 3D Printing Blood Vessel Networks



University of Pennsylvania ✓



13,123

<https://youtu.be/9VHFlwJQIkE?t=41s>

158,101



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# Industrial 3D Printing in Action



voxeljet technology VX 4000 industrial 3D printer



AIDA Mataró

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<https://youtu.be/uMMwtQts7pc?t=22s>

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# Use cases for 3D Printing across the Health Sciences



By: Press Release Nation

# Baltimore Startup's Kickstarter Raises \$7000+ in less than 24 hours



Discovery Channel's Big Brain Theory winning engineer, Corey Fleischer, introduces new product, The ARC, a 3D printed device for posture and pain relief, on Kickstarter,

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June 16, 2015

Edition: U.S. ▼



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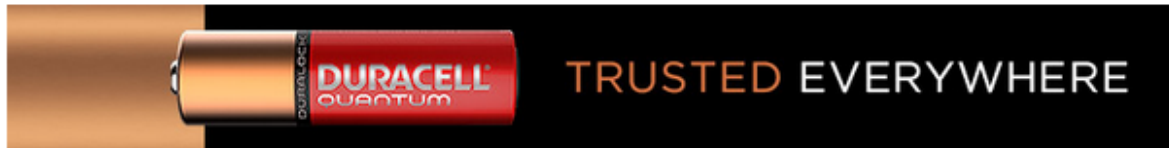
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## Dad Uses 3D Printer To Make His Son A Prosthetic Hand (VIDEO)

[http://www.huffingtonpost.com/2013/11/04/dad-prints-prosthetic-hand-leon-mccarthy\\_n\\_4214217.html](http://www.huffingtonpost.com/2013/11/04/dad-prints-prosthetic-hand-leon-mccarthy_n_4214217.html)

Posted: 11/04/2013 7:05 pm EST | Updated: 11/04/2013 7:05 pm EST



Leon McCarthy was born without fingers on his left hand, but with some help from his dad, he can now draw, pick up food and hold a water bottle using a homemade prosthetic.

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**DEC 2013**

## NOT IMPOSSIBLE'S "PROJECT DANIEL" USES 3D PRINTERS TO MAKE PROSTHETIC ARMS FOR CHILDREN OF WAR IN SOUTH SUDAN

Just before Thanksgiving 2013, Mick Ebeling returned home from Sudan's Nuba Mountains where he set up what is probably the [world's first 3D printing prosthetic lab](http://www.notimpossible.com/labs/project-daniel) and training facility. More to the point of the journey is that Mick managed to give

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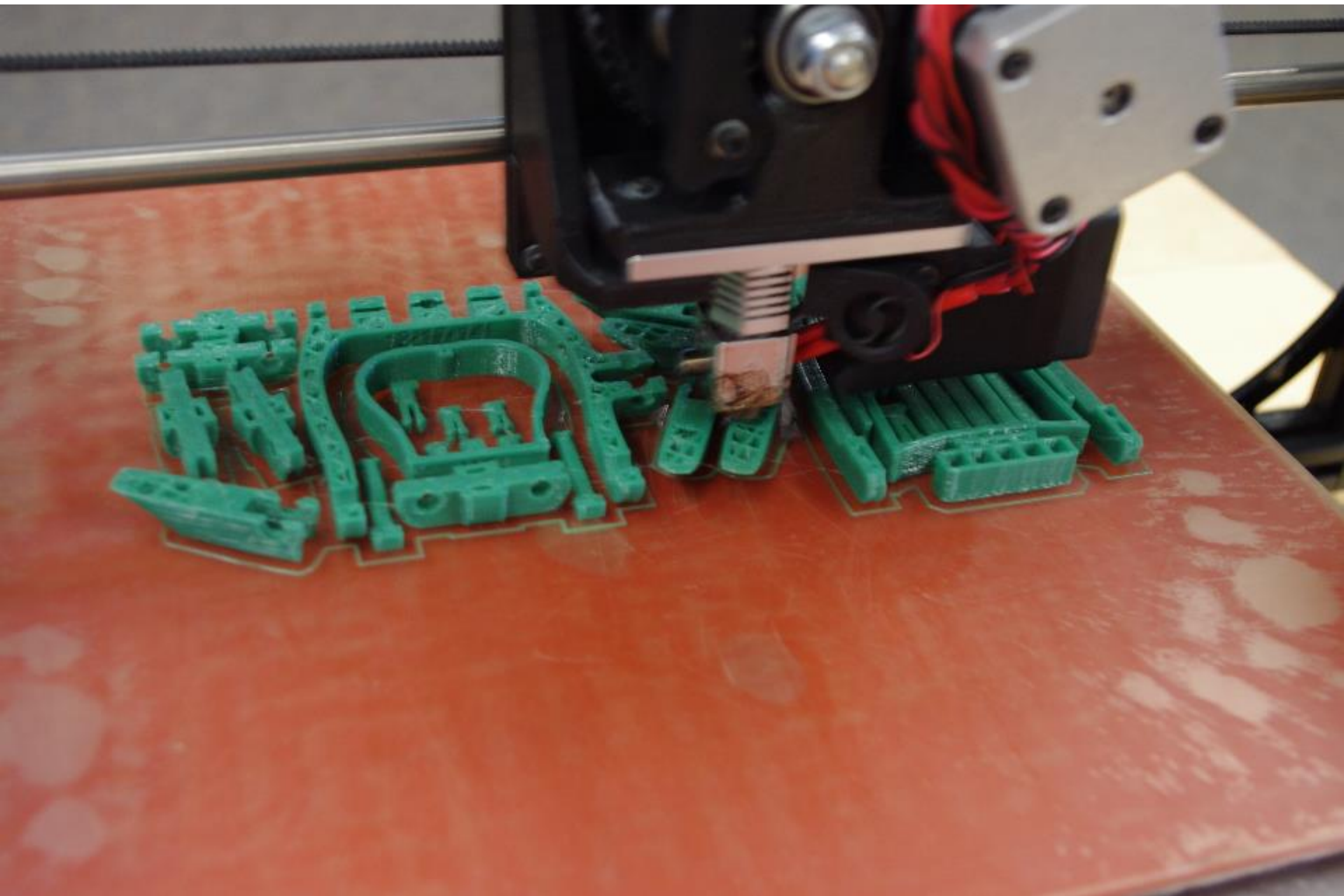
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**g+1**

25  
[Read the Full Press Release](#)

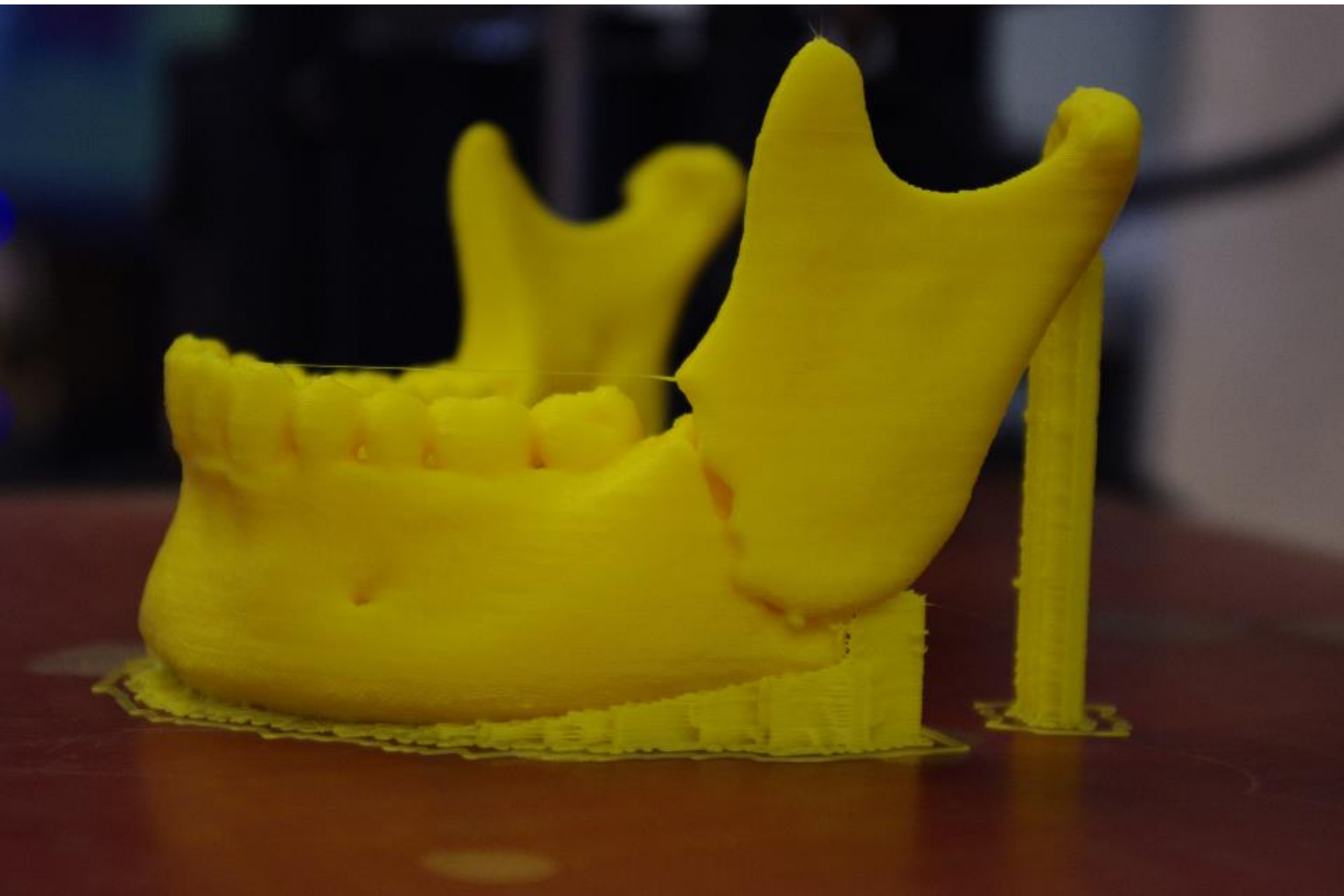
















# The FDA has approved the first drug made by a 3D printer



Source: <http://qz.com/471030/the-fda-has-approved-the-first-drug-made-by-a-3d-printer/>





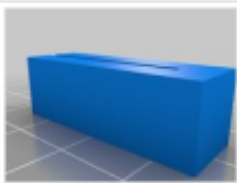
# Custom Lab Equipment



Customizable 90 degree optical post adaptor [🔗](#)



Retinal Projection Display [🔗](#)



Spectroelectrochemical cuvette insert [🔗](#)



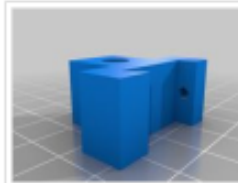
Open Mini Spectrometer [🔗](#)



PLOTS smartphone spectrometer [🔗](#)



Public Lab Smartphone Spectrometer v4 [🔗](#)



1/4" Optical Fiber Dovetail Chuck Mount [🔗](#)



Short travel manual translation stage [🔗](#)



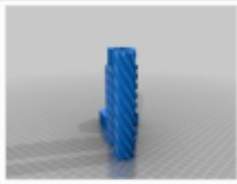
DIY Linear Translational Stage - Micrometer resolution [🔗](#)



Open Sonnar - The 3D Printable Lens Focusing Mechanism [🔗](#)



Coffee/liquid spectrometer endosure [🔗](#)



telescopic linear screw [🔗](#)



T-Ring - telescope adaptor - DSLR to telescope [🔗](#)



Z-Stage Assembly [🔗](#)



AZIZ Mini USB microscope ring light [🔗](#)



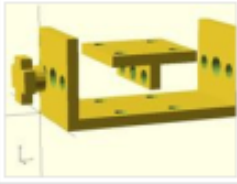
AZIZ 85mm ring light for Leica microscope [🔗](#)



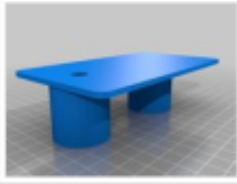
Telescope Laser Mount [🔗](#)



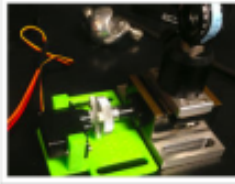
Polarizer Mount [🔗](#)



Modular (Stackable) 1-Axis Manual Positioning Stage [🔗](#)



Microscope adapter for camera [🔗](#)



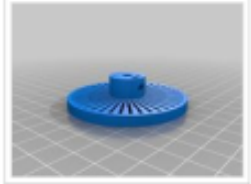
Customizable Optics Table Servo Mount [🔗](#)



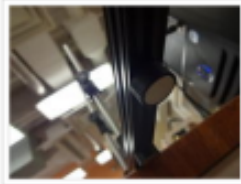
Thorlabs 25mm construction rail replica [🔗](#)



A Fully Printable Microscope [🔗](#)



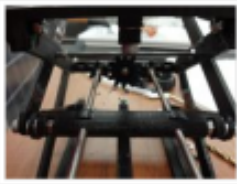
Customizable Chopper Wheel [🔗](#)



Open Source Optical Rail from OpenBeam - Magnetic Base [🔗](#)



Parametric Automated Filter Wheel Changer [🔗](#)



Open-source lab Jack [🔗](#)



Open-source Optical Rail Mount for OpenBeam [🔗](#)



Customizable Lens Holder [🔗](#)



Square Filter Holder for Open-source Optics [🔗](#)

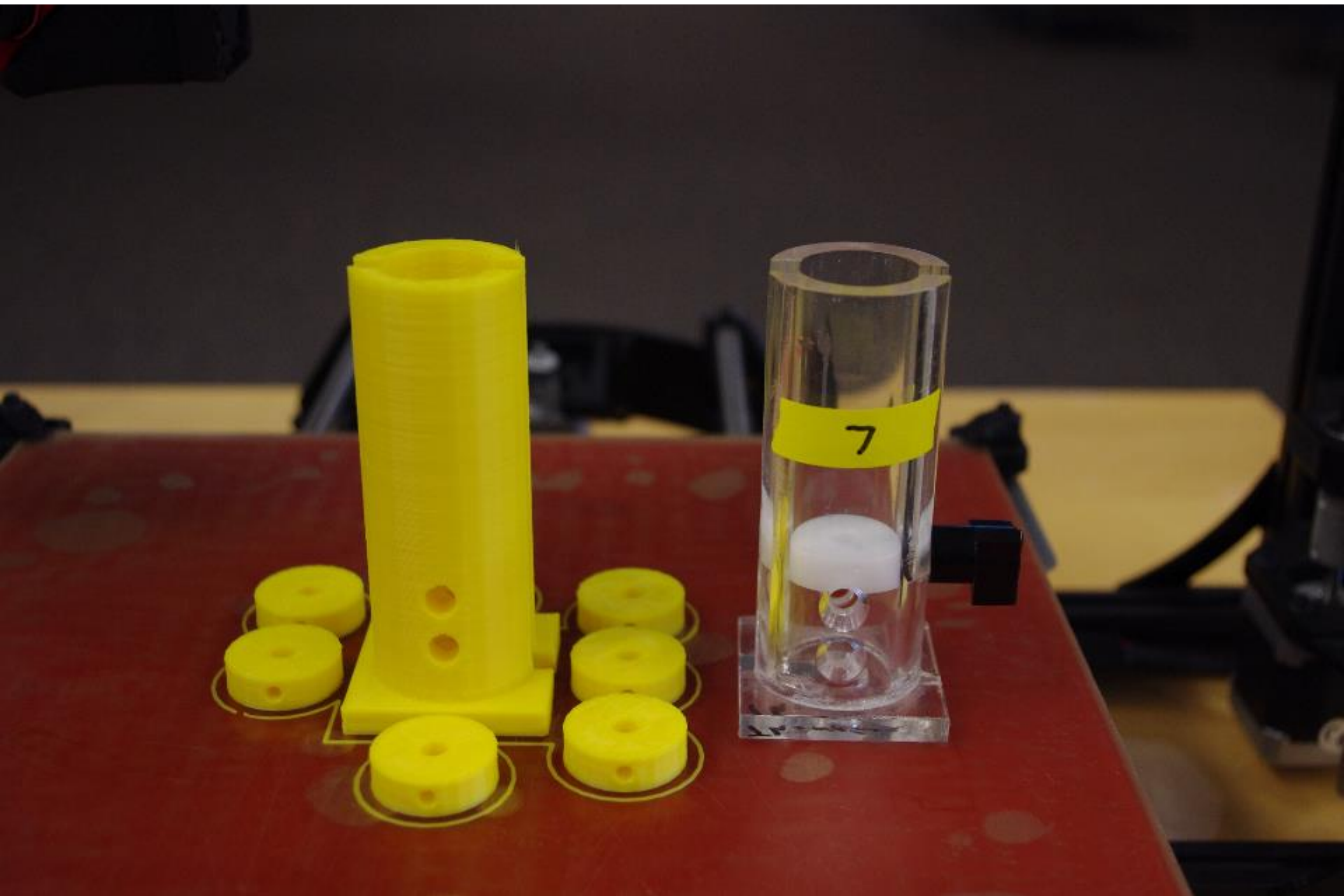


OpenBeam Optical Rail Simple Rod Holder [🔗](#)



Open-source magnetic optics base [🔗](#)

source: [http://www.appropedia.org/Open\\_source\\_optics](http://www.appropedia.org/Open_source_optics)



# Common uses of 3D Printing across the Health Sciences


- Anatomical objects
- Prosthetic limbs
- Medical & clinical devices
- Custom lab equipment
- Bio matter - cells/tissue/organs, food, drugs


# 3D Printing Going Mainstream

- Broadly adopted in health sciences and beyond
- Commercially available desktop printers
- Global & local “maker space” movement
- UMB’s Innovation Space has 3D printers and scanners

# 3D Model Examples

**MakerBot Thingiverse** DASHBOARD EXPLORE CREATE  SIGN IN / JOIN

 **CT Scan of Mouse Femur (half)**  
by 10monthspregnant, published Sep 12, 2014



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Instructions

Thing Files

0 Comments

0 Made

2 Collections

0 Remixes

<http://www.thingiverse.com/thing:460437>



# Finding .STL 3D Model Files

- [NIH 3D Print Exchange](#)
- [Thingiverse](#)
- [Instructables](#)
- [3D Warehouse](#)
- [GrabCAD](#)
- [Ponoko](#)
- [Nervous System](#)
- Not all 3D model files found here are 3D printable!


More information at

<http://guides.hshsl.umaryland.edu/c.php?g=163717&p=1075331>

<http://www.thingiverse.com/>


131 results for "prosthetic": THINGS ▼


Sort: RELEVANT ▼






**The Prosthetic Hand Kit**  
by spedzero

May 2, 2010





 37
  46
  3



**Ody Hand RP 1.0 (a Prost...**  
by MacGyvrBot

Jun 8, 2014



 33
  41
  1



**Multiplexed Prosthetic De...**  
by sandrabaskharon

Apr 21, 2015



 9
  3
  0




**Prosthetic Hand for design...**  
by MacGyvrBot

Aug 7, 2014







 59
  54
  6




**InMoov finger prosthetic ...**  
by hairygael

Jul 14, 2013







 144
  153
  8



**Prosthetic/Robotic Hand ...**  
by profhankd

Oct 1, 2013



 99
  94
  11  
39

# NIH 3D Print Exchange

U.S. Department of Health and Human Services — National Institutes of Health

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NIH 3D Print Exchange

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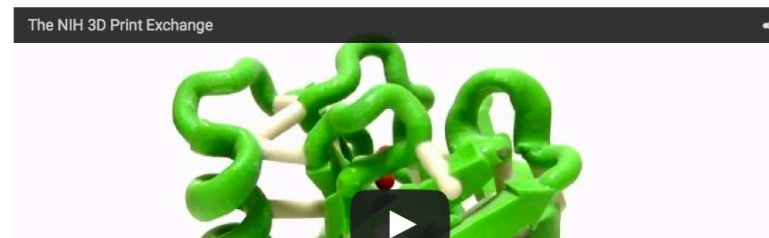


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ENGAGE

3D printing technology is advancing at a rapid pace, but it is difficult to find or create 3D-printable models that are scientifically accurate or medically applicable. The NIH 3D Print Exchange provides models in formats that



## Special Collections



Prosthetics

Curated by e-NABLE



Neuroscience

Curated by EyeWire



Heart Library

Sponsored by Jump Simulation

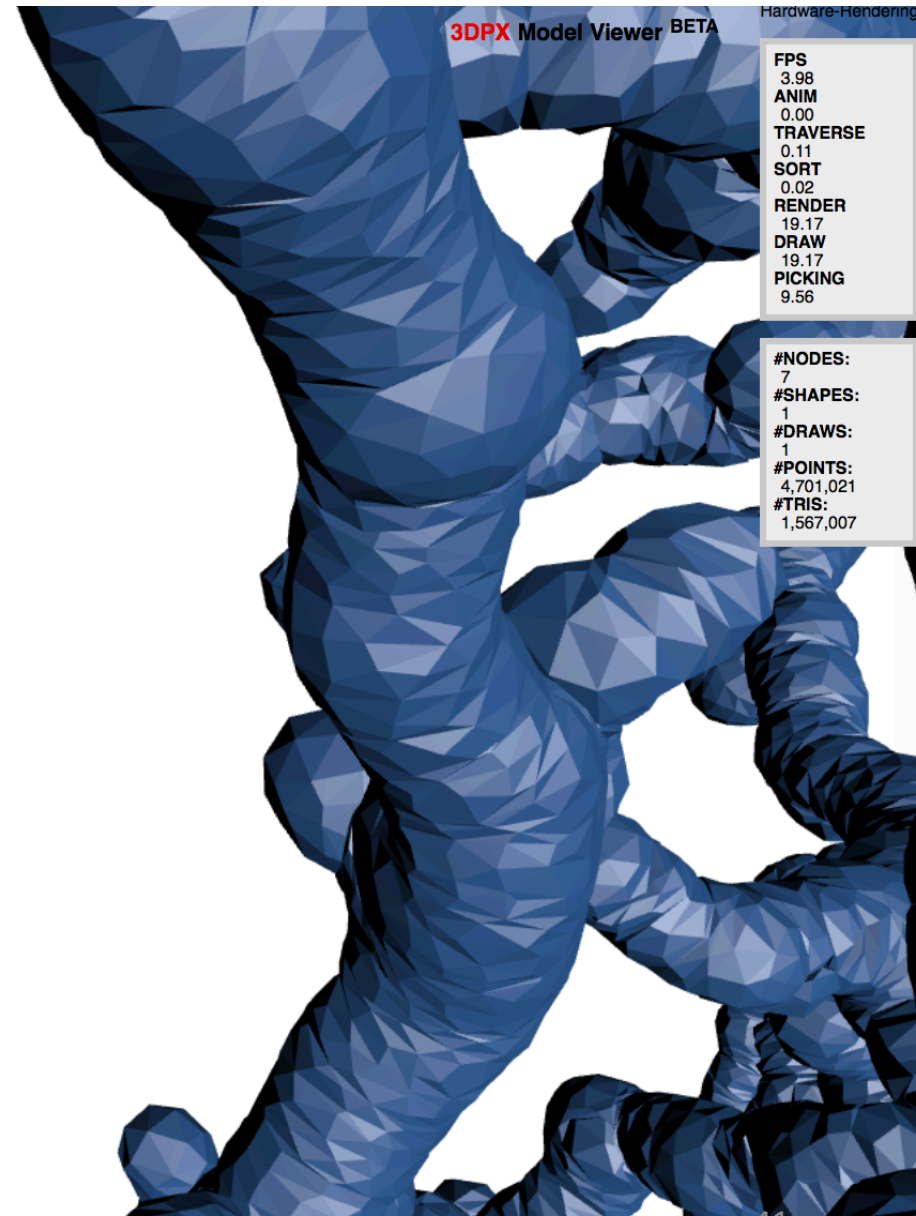
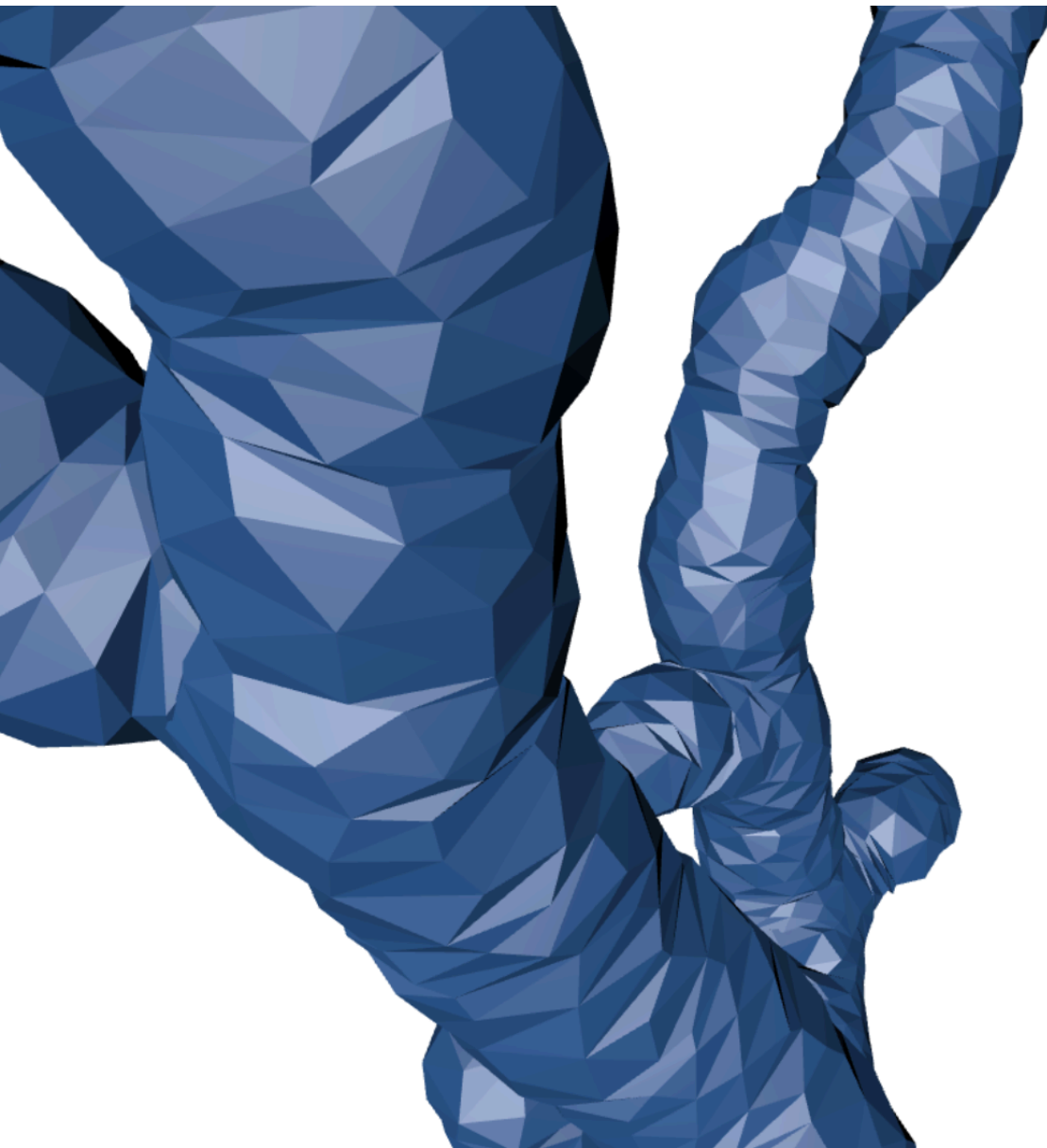


Molecule of the Month

by the RCSB Protein Data Bank

<http://3dprint.nih.gov/>

# Triangles in a Mesh





# 3D Mesh Modeling

- A **mesh** is a collection of vertices, edges, and faces that describe the shape of a 3D object.
  - A **vertex** is a single point.
  - An **edge** is a straight line segment connecting two vertices.
  - A **face** is a flat surface enclosed by edges. (Some other applications call these "polygons")
- Source:  
[http://en.wikibooks.org/wiki/Blender\\_3D: Noob to Pro/What is a Mesh%3F](http://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro/What_is_a_Mesh%3F)

# Check if the File Can be 3D Printed

- **Correct Non-Manifold Geometry Issues**
- Is your 3D model solid/watertight and has the valid 3D geometry?
  - This means that all faces are closed and they form one or more closed entity.
  - There must be no open gaps/holes, non-manifold edges, self-intersections, zero-length edges, naked edges, degenerate faces, duplicate faces, or inverted triangles.
  - Upload and repair your file through the free [NetFabb Cloud Service](https://netfabb.azurewebsites.net/) - <https://netfabb.azurewebsites.net/>
  - Download the repaired version.
  - (Optionally, you may use other software to do the repair.)

## HS/HSL Innovation Space



### Welcome to the HS/HSL Innovation Space!

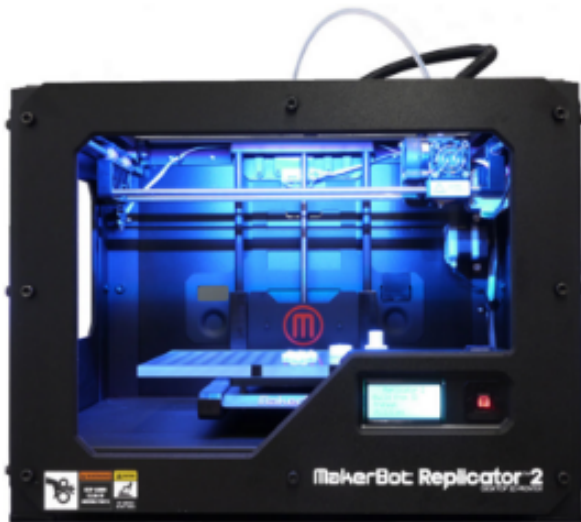
The Innovation Space is designed for innovative and collaborative hands-on learning experience. It offers two 3D printers, a 3D scanner, over 3,500 video tutorials from Lynda.com, a large DNA model, two molecule kits, a button maker, and a 3D printing pen. The staff provides an orientation as well as workshops on a regular basis for those who are new to 3D printing and 3D scanning.

We encourage all UMB students, faculty, and researchers who are interested in experimenting with 3D printing and 3D scanning to visit our new Innovation Space. We are planning to expand this space in the near future with more equipment and programs. If you have any suggestions or ideas for collaboration, please contact us at [inspace@hshsl.umaryland.edu](mailto:inspace@hshsl.umaryland.edu).

# What You Can Use at the Innovation Space

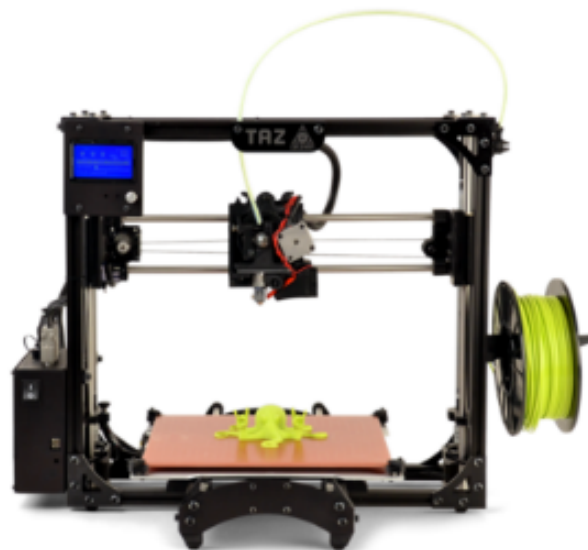
## Makerbot Replicator 2X

Relicator 2X offers two extruders. You can use ABS or dissolvable filament. Bring a .STL file with you.



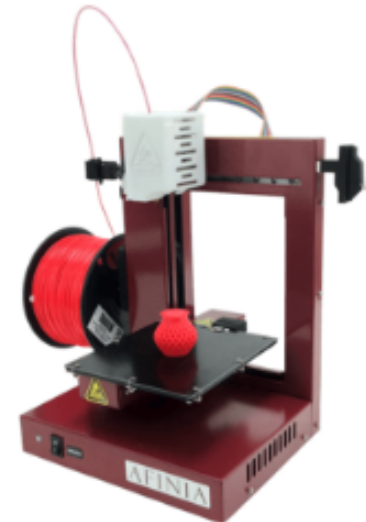
## Lulzbot Taz 5

Transform your idea into a physical object with 3D printing! Taz 5 supports a variety of materials from HIPS, PLA, and ABS, to wood, metal, and stone-like.



## Afinia H480 3D Printer

The Afinia H480 is a small but reliable 3D printer. It has one extruder and supports the PLA filament.





# What You Can Use at the Innovation Space

## Tutorials from Lynda.com

Great learning resource that offers 3,500 video tutorials by experts. Topics range from 3D modeling to computer programming. Learn how to operate a 3D printer, how to build a 3D model in Tinkercad or Blender, and how to program in Python or Ruby. (Available on-site only at the Innovation Space.)



## NextEngine 3D Laser Scanner

Create high fidelity 3D models of physical objects with our NextEngine 3D scanner and software.



## Handheld 3D Scanner

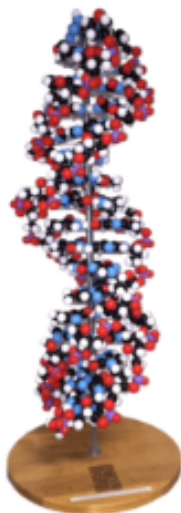
Try 3D scanning with an object of your choice! You can scan an object as small as a book or as big as a person. Yes, you can save the resulting 3D model and 3D print it!



# What You Can Use at the Innovation Space

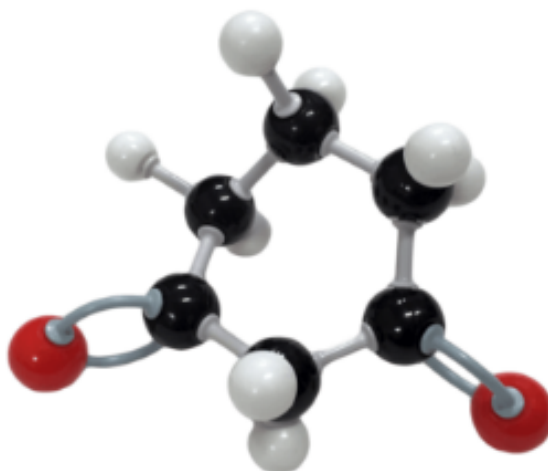
## DNA Model

Come play with the human DNA model.  
Assemble and disassemble while  
learning about the DNA structure!  
[Check out the assembly instruction.](#)



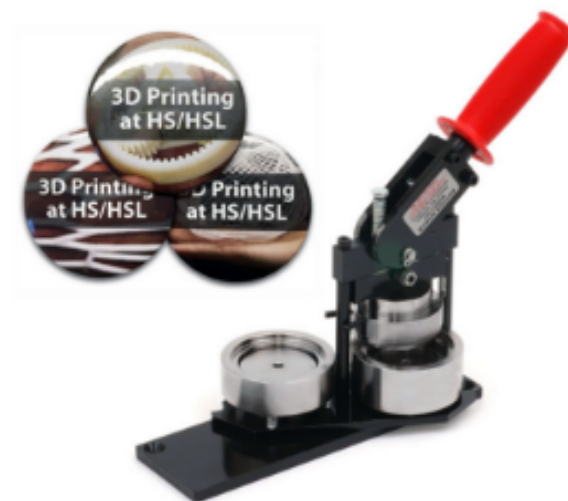
## Molecule Model

Explore the chemical structure of  
molecules! You can build methane,  
ethane, benzene, acetone, and more.



## Button Maker

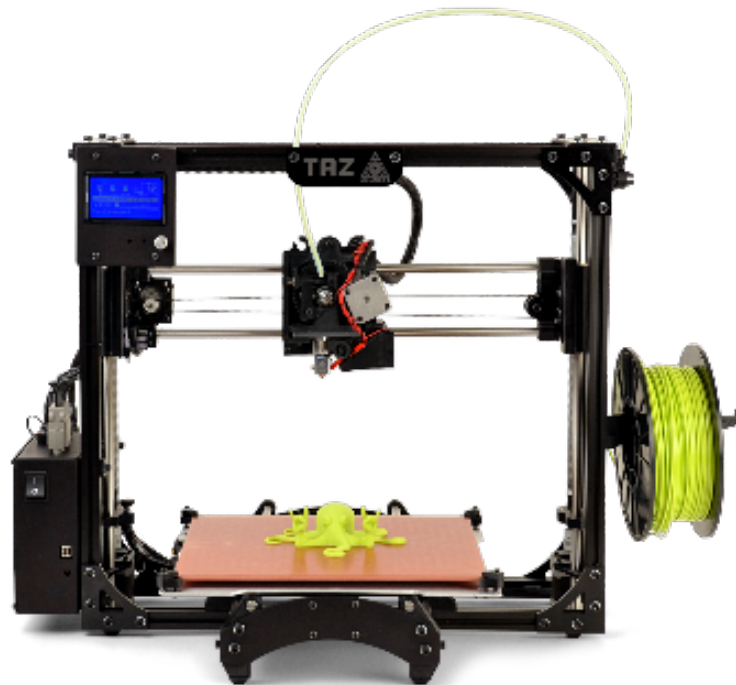
Button making is easy - if you have the  
right button making equipment! This 3"  
button making system will include  
everything you need to make high-  
quality 3" buttons.



# Taz 5

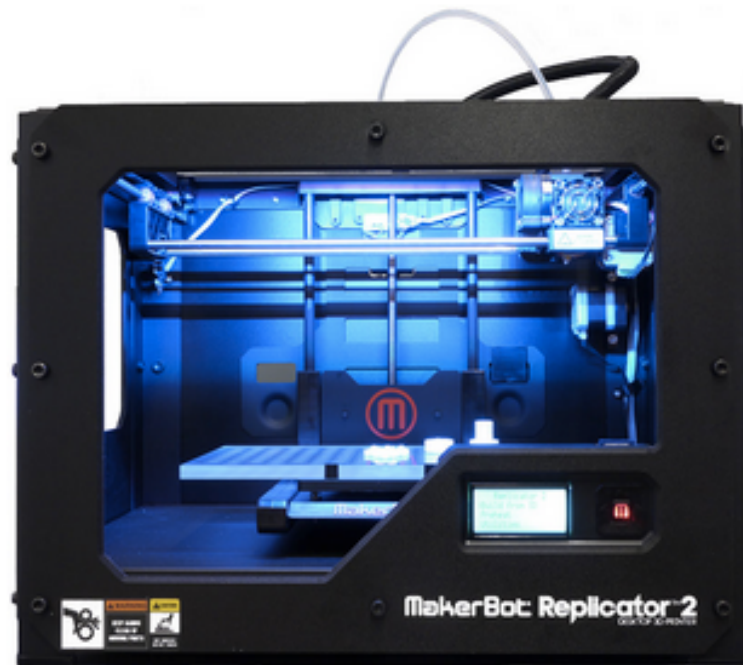
- Detailed instruction here:

<http://guides.hshsl.umaryland.edu/inspace/taz5>



# Replicator 2X

- Detailed instruction here:  
<http://guides.hshsl.umaryland.edu/c.php?g=163717&p=1598497>

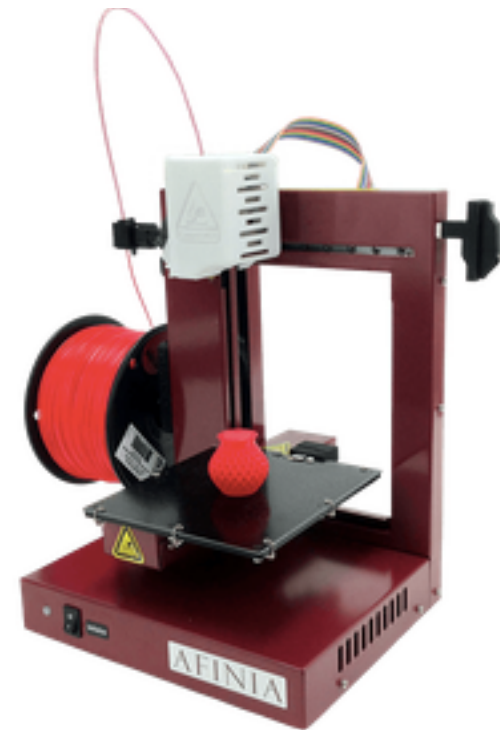




# Afinia H480

- Detailed instruction here:

<http://guides.hshsl.umaryland.edu/c.php?g=163717&p=1598500>



# Live 3D Print Web Cam



# 3D Printing Process Checklist

- <http://guides.hshsl.umaryland.edu/c.php?g=163717&p=1075333>

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HS/HSL / Guides / 3D Printing and 3D Scanning at the Innovation Space / 5. 3D Printing Process Checklist

## 3D PRINTING AND 3D SCANNING AT THE INNOVATION SPACE

Get hands-on learning experience with 3D printing and 3D scanning!

What Is 3D Printing?

3D Printing in Health  
Sciences

3D Printers at HS/HSL

How-To Guide for 3D  
Scanning

Editing a 3D Scanned  
Image with the Sense 3D  
Scanner

How-To Guide for 3D









### 5. 3D PRINTING PROCESS CHECKLIST

**\*You must '[Prepare and Repair Your 3D Model as a .STL file](#)' before starting a 3D print job.\***

1. Check with the CATS staff if the [maintenance has been recently performed](#).
2. For the successful 3D printing, the platform needs to be leveled properly, and both the platform and the extruder need to be clean.
3. You may apply or replace the blue painter's tape on the plate to remove the printed object more easily.
4. Make sure you have enough filament on the spool.

# After this workshop,

- Make a reservation for orientation/use!  
<http://cal.hshsl.umaryland.edu/booking/inspace>.

 <a href="#">Make a Reservation Online</a>	 <a href="#">Sign up for the 3D Printing Workshop</a>
 <b>Hours:</b> Monday - Friday, 9 a.m. – 6 p.m. (3 hrs. max. All 3D printing jobs must end by 6 pm.)	 <a href="#">Use &amp; Cost Policy</a> (\$3 for up to an hour of 3D printing & \$1 for each additional hour)
 <b>Contact Us:</b> <a href="mailto:inspace@hshsl.umaryland.edu">inspace@hshsl.umaryland.edu</a>	 <a href="#">How-To Guide for 3D Printing</a>
 <a href="#">Watch the 3D Printer in Action</a>	 <a href="#">How-To Guide for 3D Scanning</a>

- Prototype, create, collaborate!



# Contact Us!

- E-mail [ispace@hshsl.umaryland.edu](mailto:ispace@hshsl.umaryland.edu)
- HS/HSL Innovation Space:  
<http://www.hshsl.umaryland.edu/services/ispace/>
- 3D Printing/3D Scanning How-To Guide  
<http://guides.hshsl.umaryland.edu/ispace>

# 3D Printing at the Innovation Space

How-To Guide for 3D Printing <http://guides.hshsl.umaryland.edu/inspace/>

## What Is 3D Printing?

### 3D Printing in Health Sciences

### 3D Printers at HS/HSL

## How-To Guide for 3D Printing

### 1. Get Yourself a 3D Model File

### 2. Prepare Your 3D File and Correct Non-Manifold Geometry Issues

### 3. 3D Printing with the Taz 5

### 4. 3D Printing with the Replicator 2X

### 5. 3D Printing with the Afinia H480

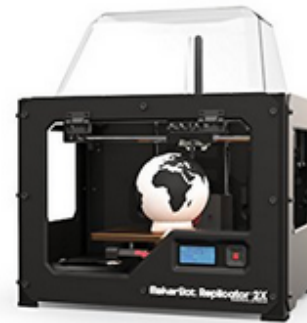
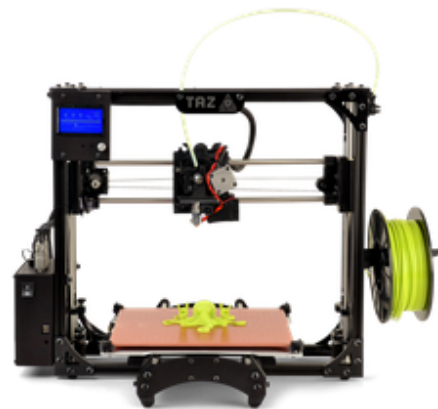
### 6. 3D Printing Process Checklist

### 7. Troubleshooting

## Terms in 3D Printing

## 3D Printers at HS/HSL

[Lulzbot Taz 5](#), [MakerBot Replicator 2X](#) and [Afinia H480](#) are available. All three of them utilize the [Fused deposition modeling](#) method,



## 3D Printer Models

- [Lulzbot Taz 5](#)
  - [Quick Start Guide \[PDF\]](#)
  - [User Manual \[PDF\]](#)
  - [Cura Lulzbot Edition Manual \[PDF\]](#)
- [MakerBot Replicator 2X](#)