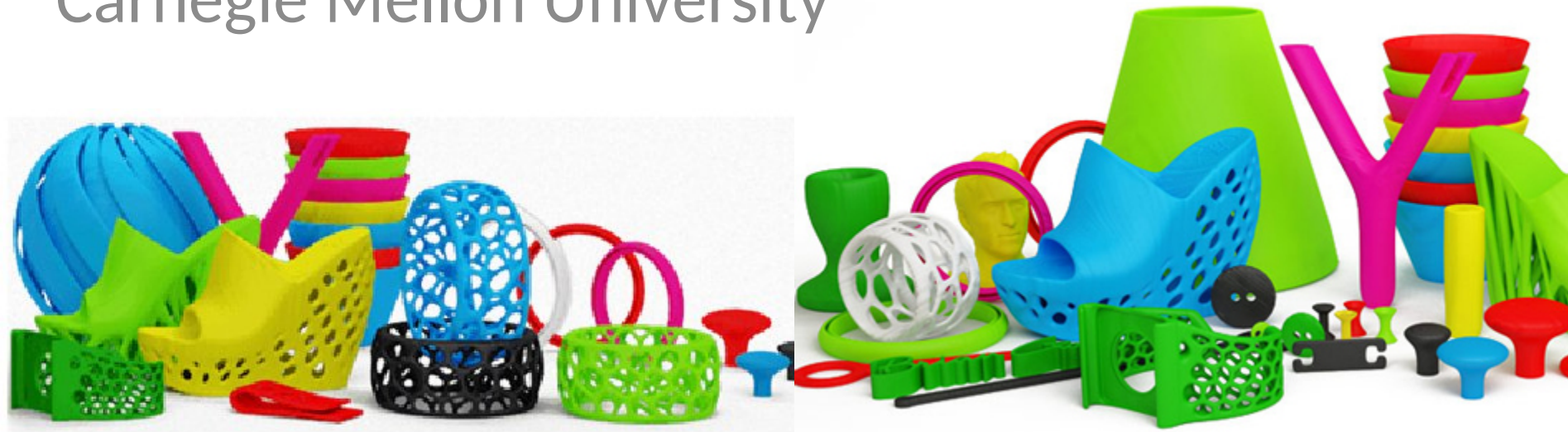


# 15-294 Rapid Prototyping Technologies: Molecule Exercise and 3D Printer Intro

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# 3D Printer vs. Laser Cutter

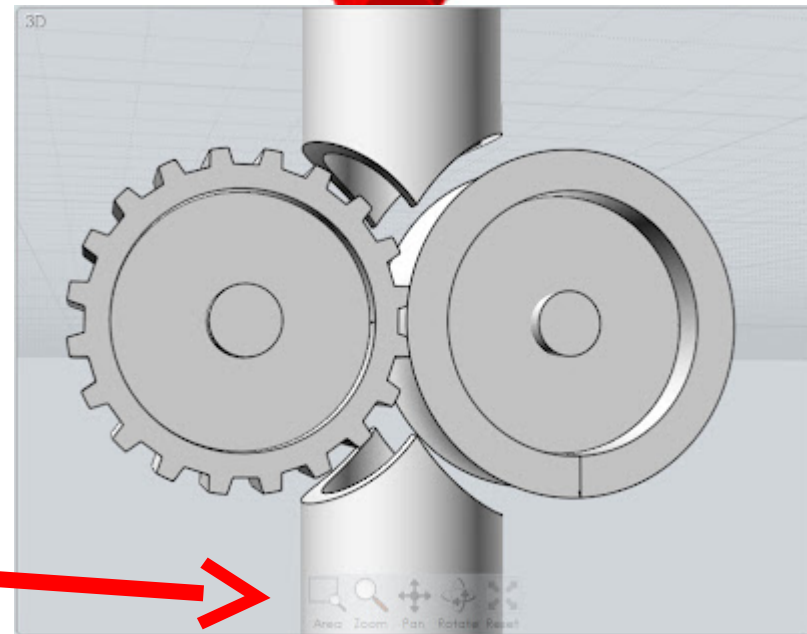
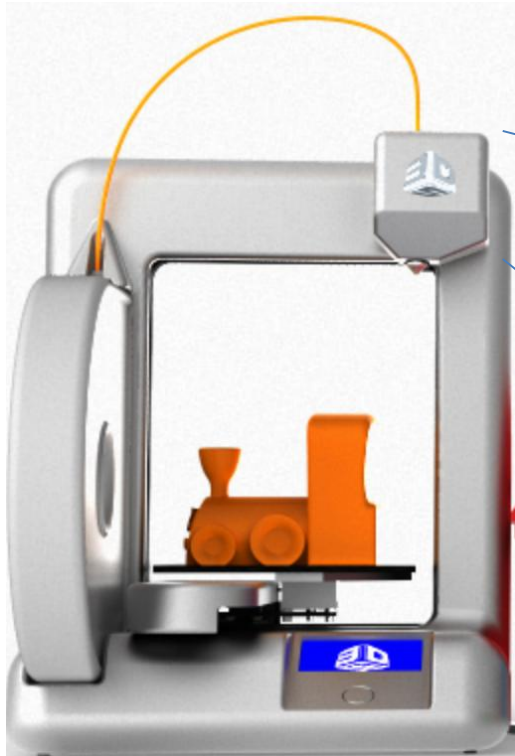
- ✗ Slower
- ✗ Less precise
- ✗ More expensive
- ✗ Limited materials
- ✗ Support material may be required
- ✓ Complex 3D structures!



# Low Cost 3D Printers

- RepRap: 2005 onward
  - Adrian Bowyer, University of Bath (UK)
  - Goal: open source 3D printer that can replicate itself
  - 4 generations: Darwin, Mendel, Prusa Mendel, Huxley
  - Spawned many start-ups
- Makerbot
  - Evolved from RepRap; initially was open source
  - Cupcake, Thing-o-Matic, Makerbot2, Replicator
- Solidoodle (\$500)
- Zortrax M-200
- Many, many more...

# The Cube 2 Extruder



Heated section

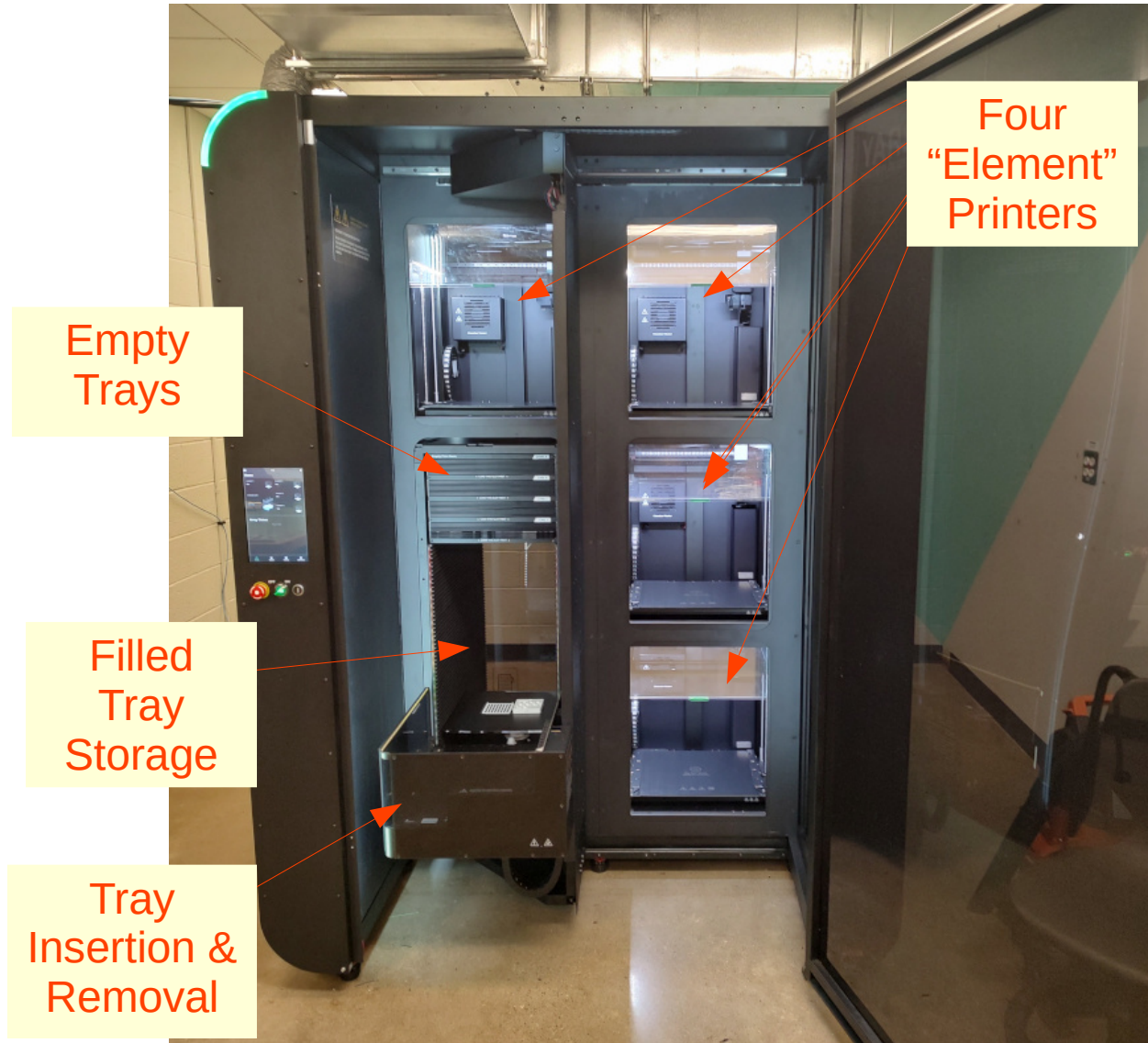
Image from cubifyfans.blogspot.com



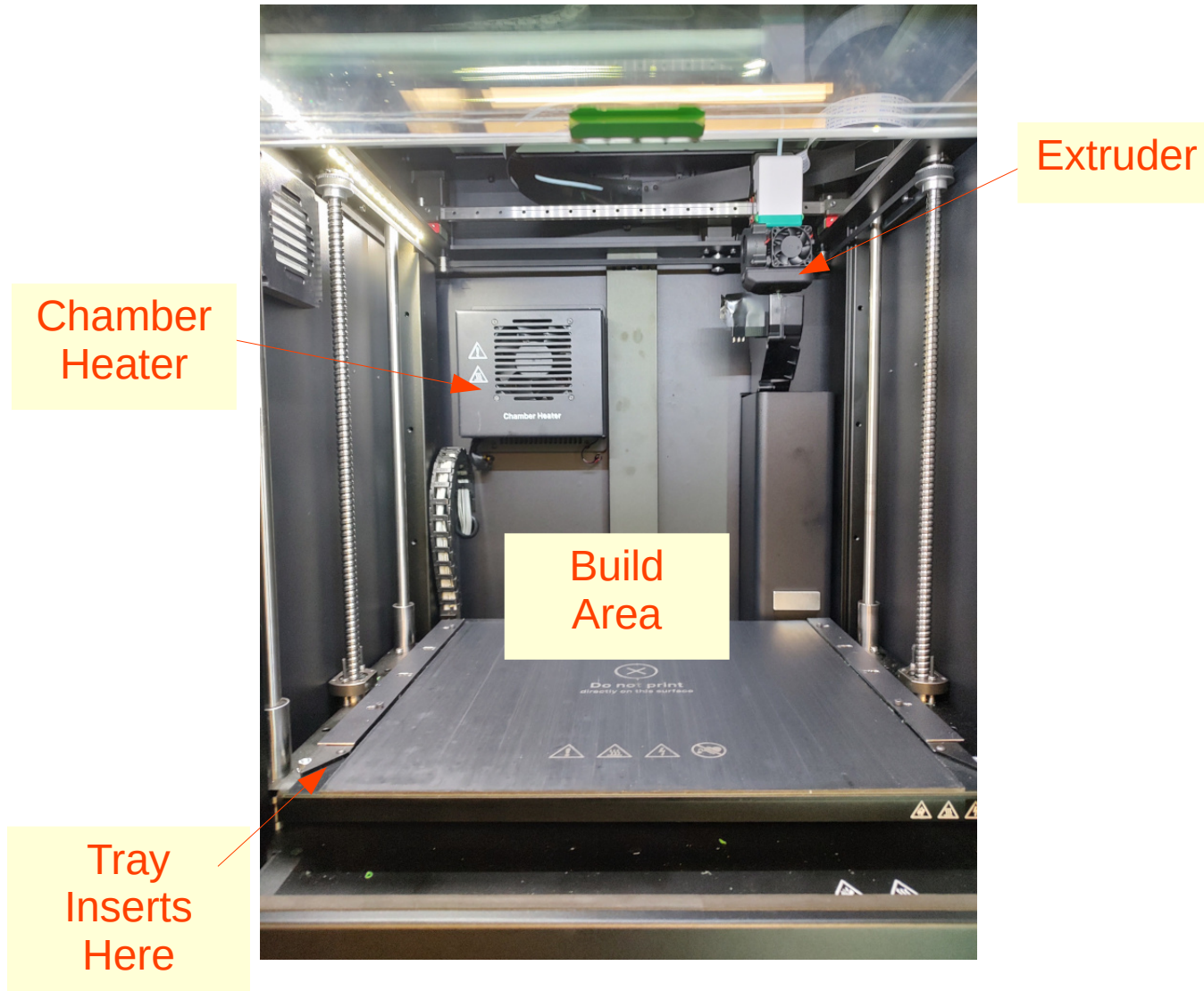
# Mosaic's 3D Printer Array



# Mosaic's 3D Printer Array



# An “Element” Printer





# Coarse vs. Fine STL Triangulation

- Too coarse can lose detail, but too fine can also cause features to be lost.
  - SolidWorks “fine” (under “Options” when you save an STL file) seems to be okay, but don’t go to “custom” and crank up resolution to the max.



# Changing the Amount of Infill

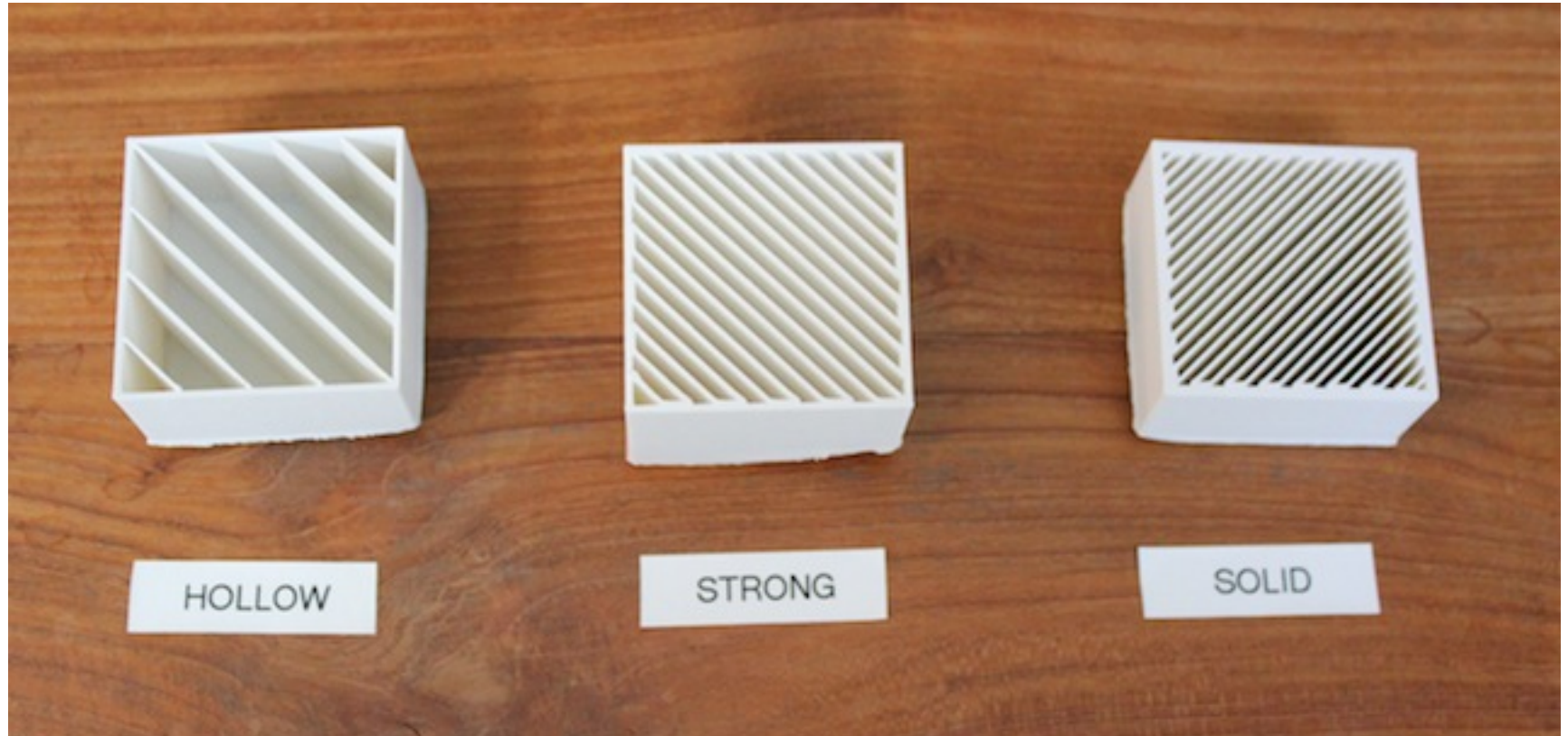
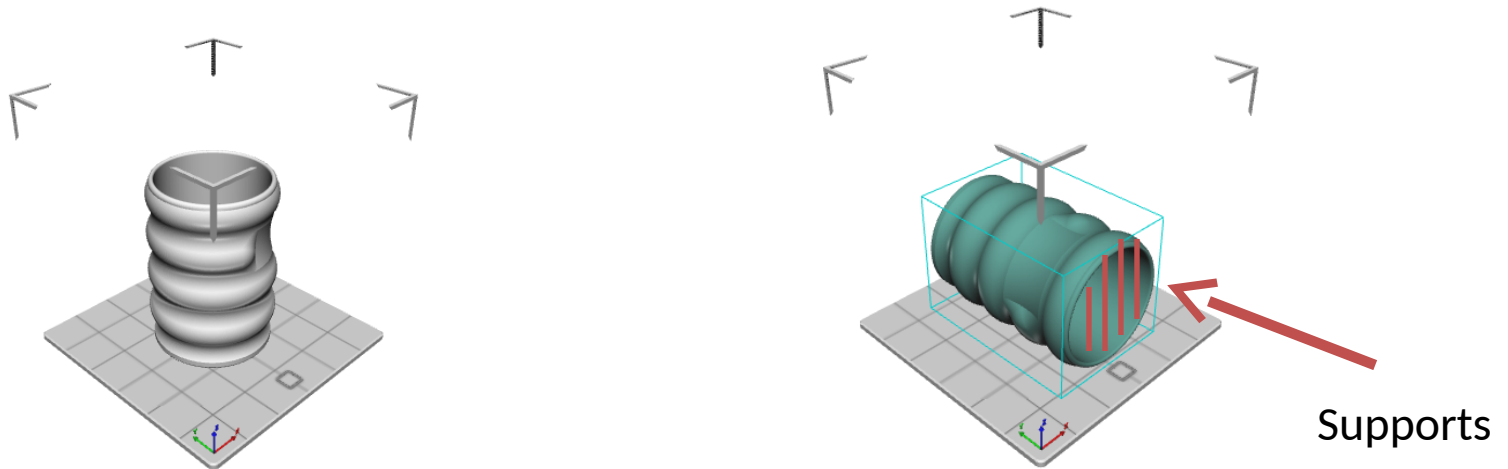


Image from cubify.com

# Part Orientation

- Choose your part orientation to avoid the need for supports if possible.
- Don't put supports where they will be difficult to remove.

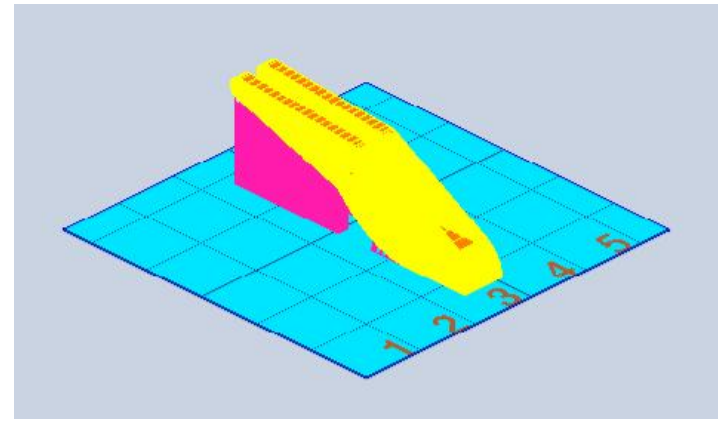
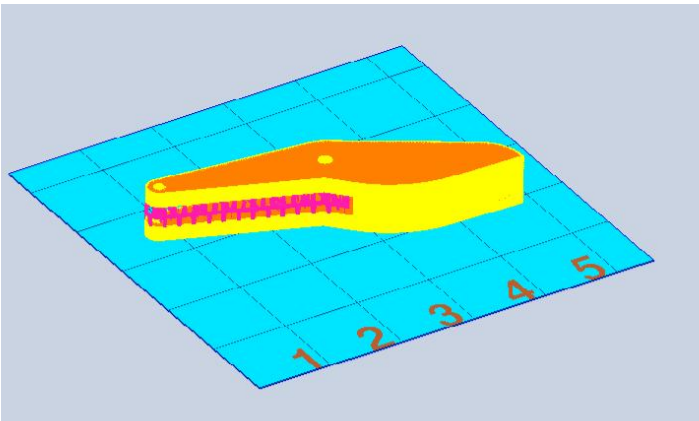


- Remember: supports leave a rough surface.



# Part Orientation

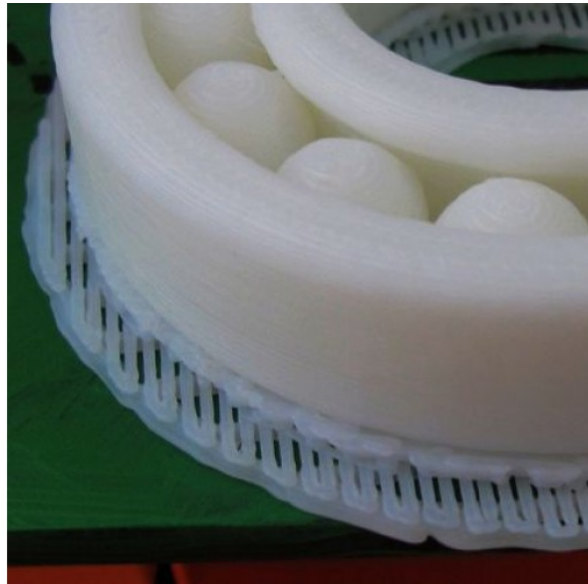
- Sometimes the use of support material is unavoidable.
- Don't put supports where they will be difficult to remove.



- Remember: supports leave a rough surface.

# Use of a Raft

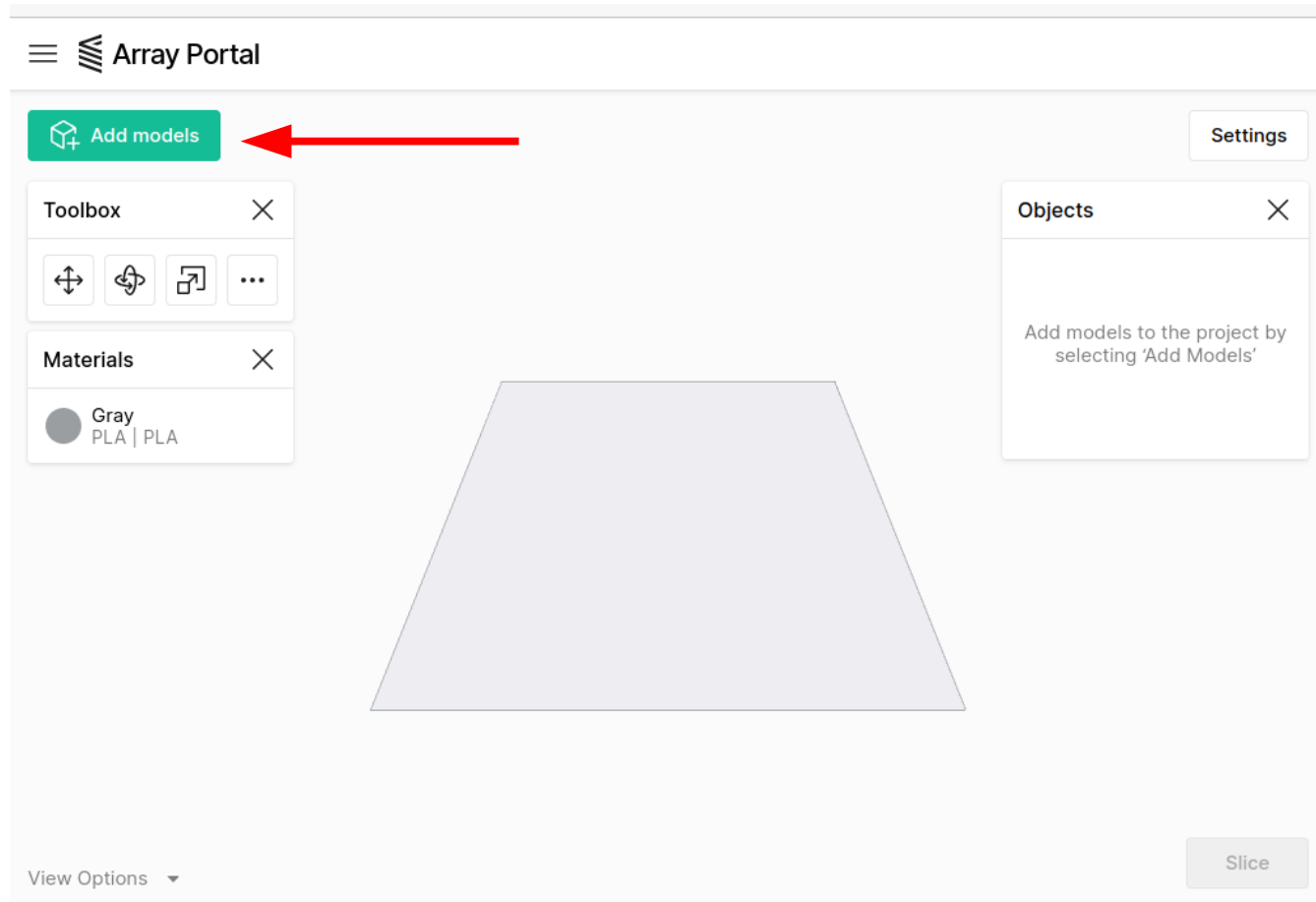
- Why use a raft?
  - Stable base of support for tall, skinny parts.
  - Prevents warping of big smooth parts (like cases) by reducing surface contact with heated bed (1st gen. Cubes only).
- Why avoid a raft?
  - Ruins the part finish (get out your sandpaper).
  - Takes more time and more plastic to print.



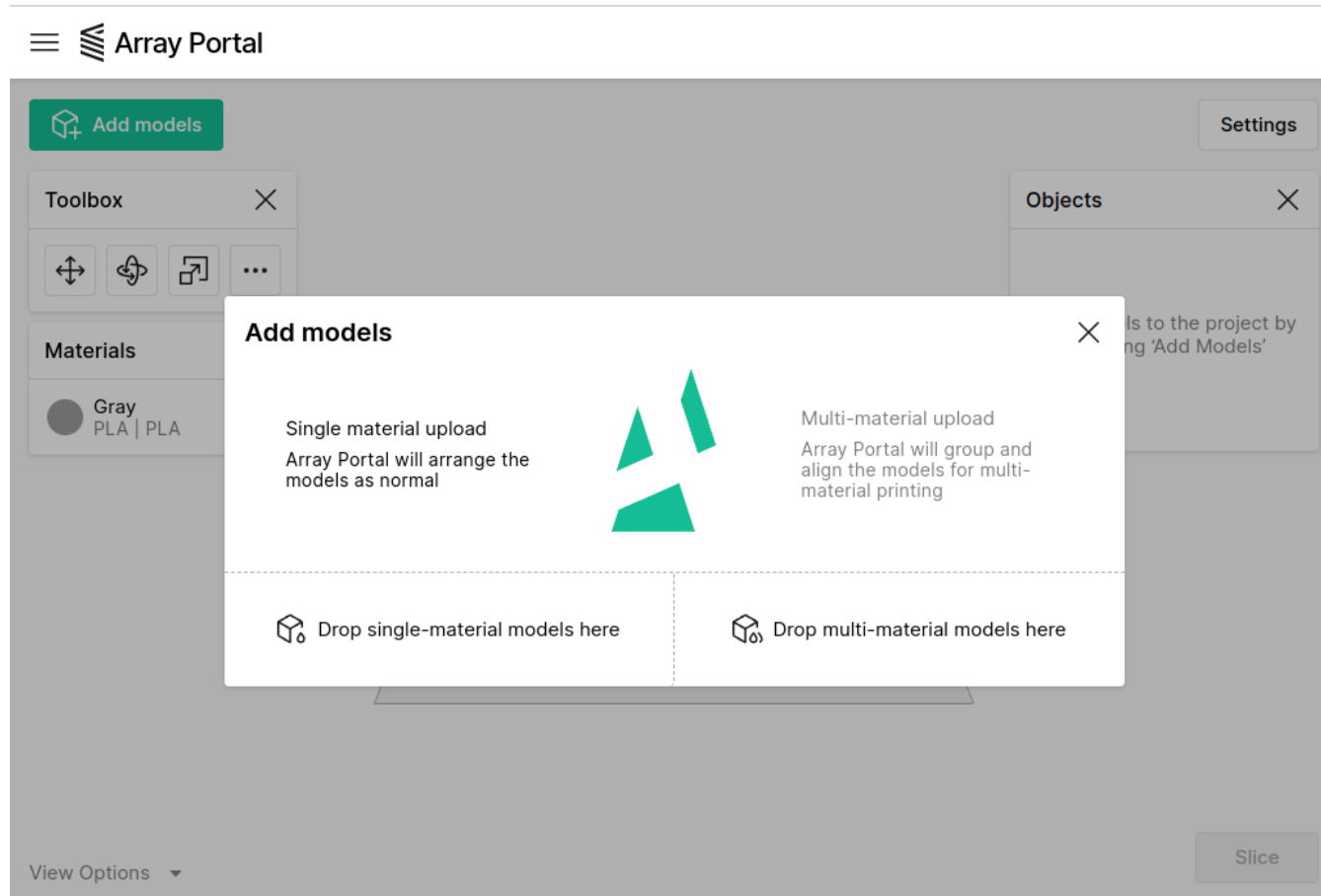
# How to Print Your Molecule

1. From the course home page, click on “IDeATe Array Portal” and create a submission.
2. Check your email.
3. Click on the project link in the email.
4. Then follow these steps...

# Click on “Add models”



# Upload Your STL File

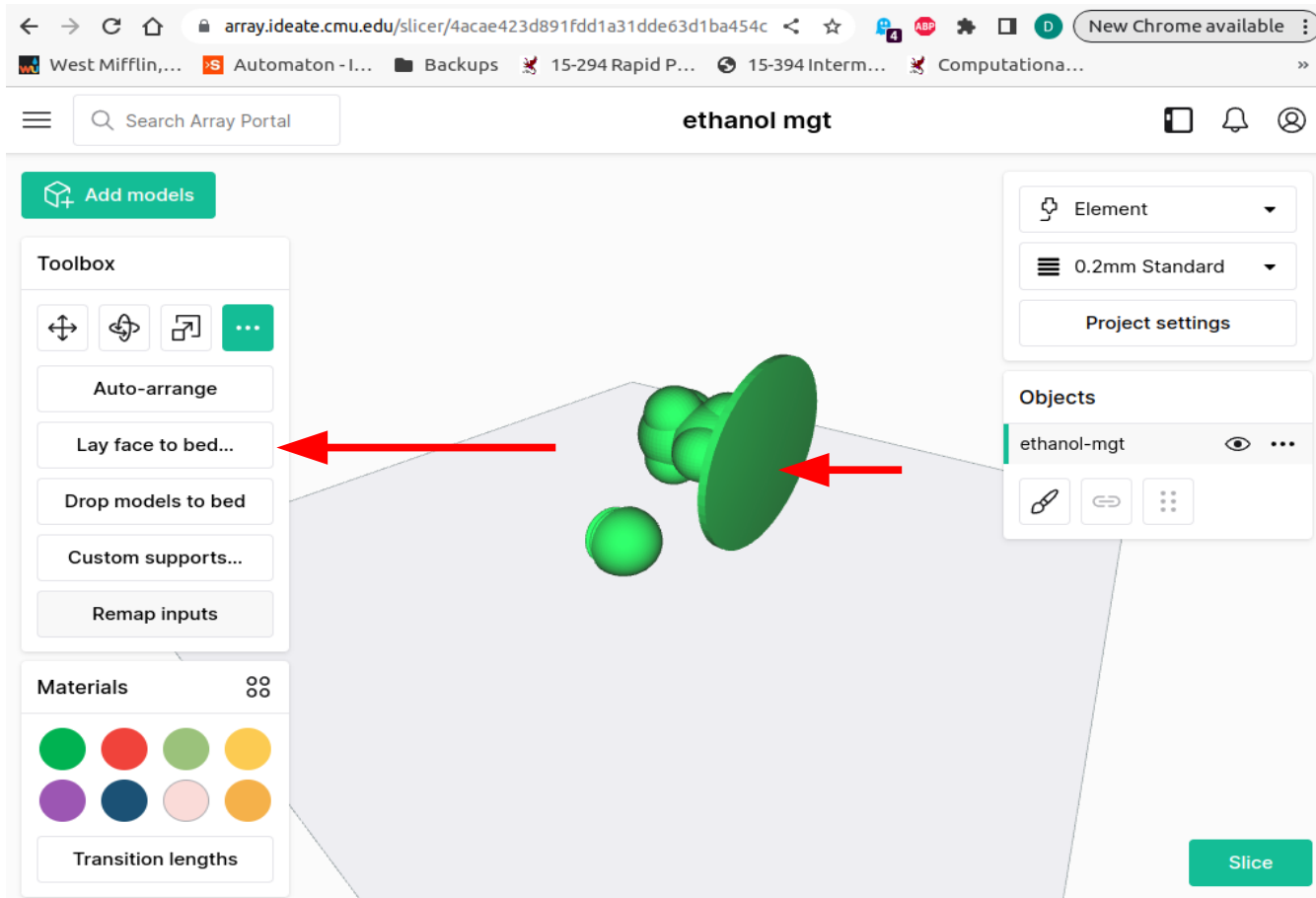


# Open the Toolbox

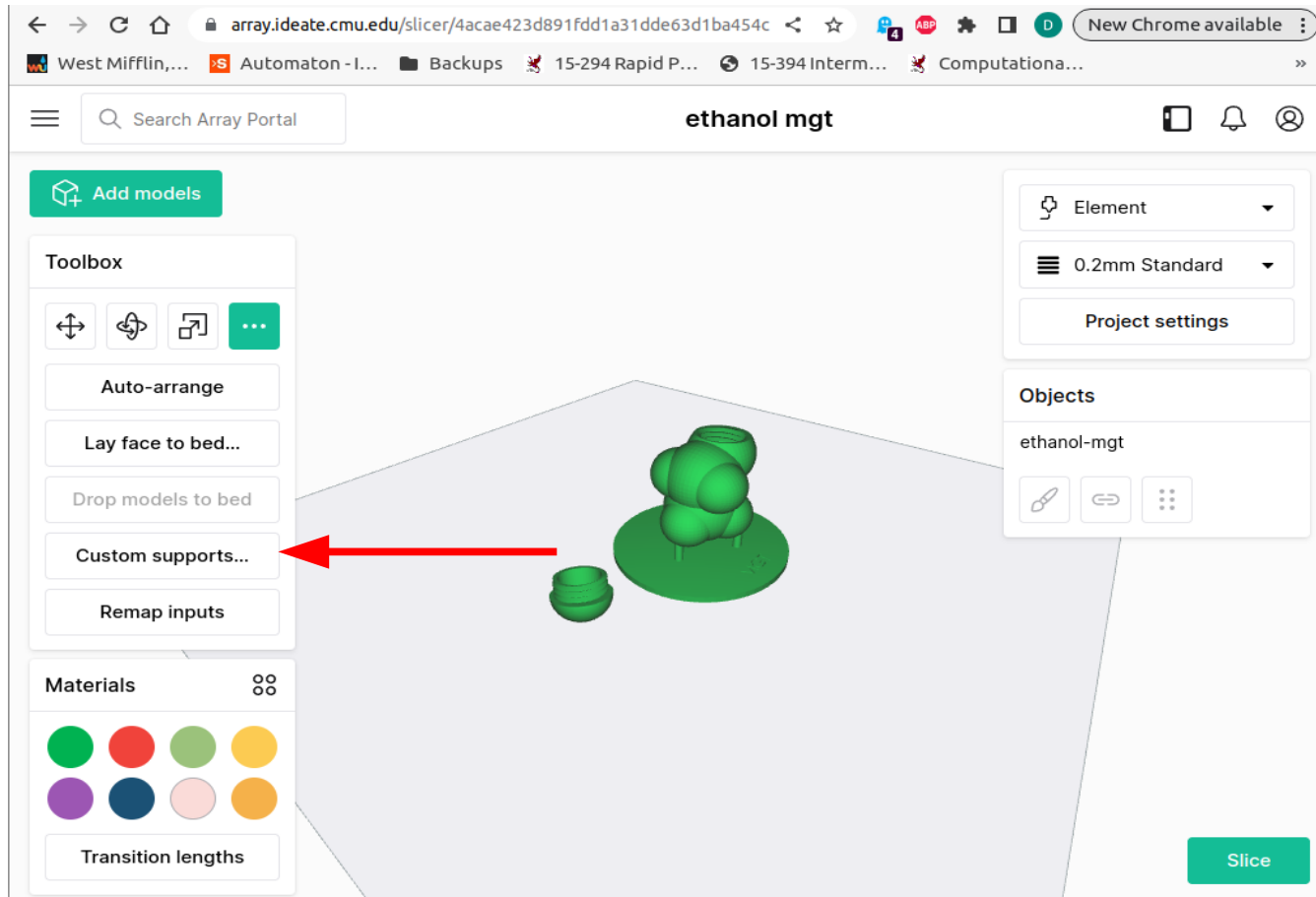




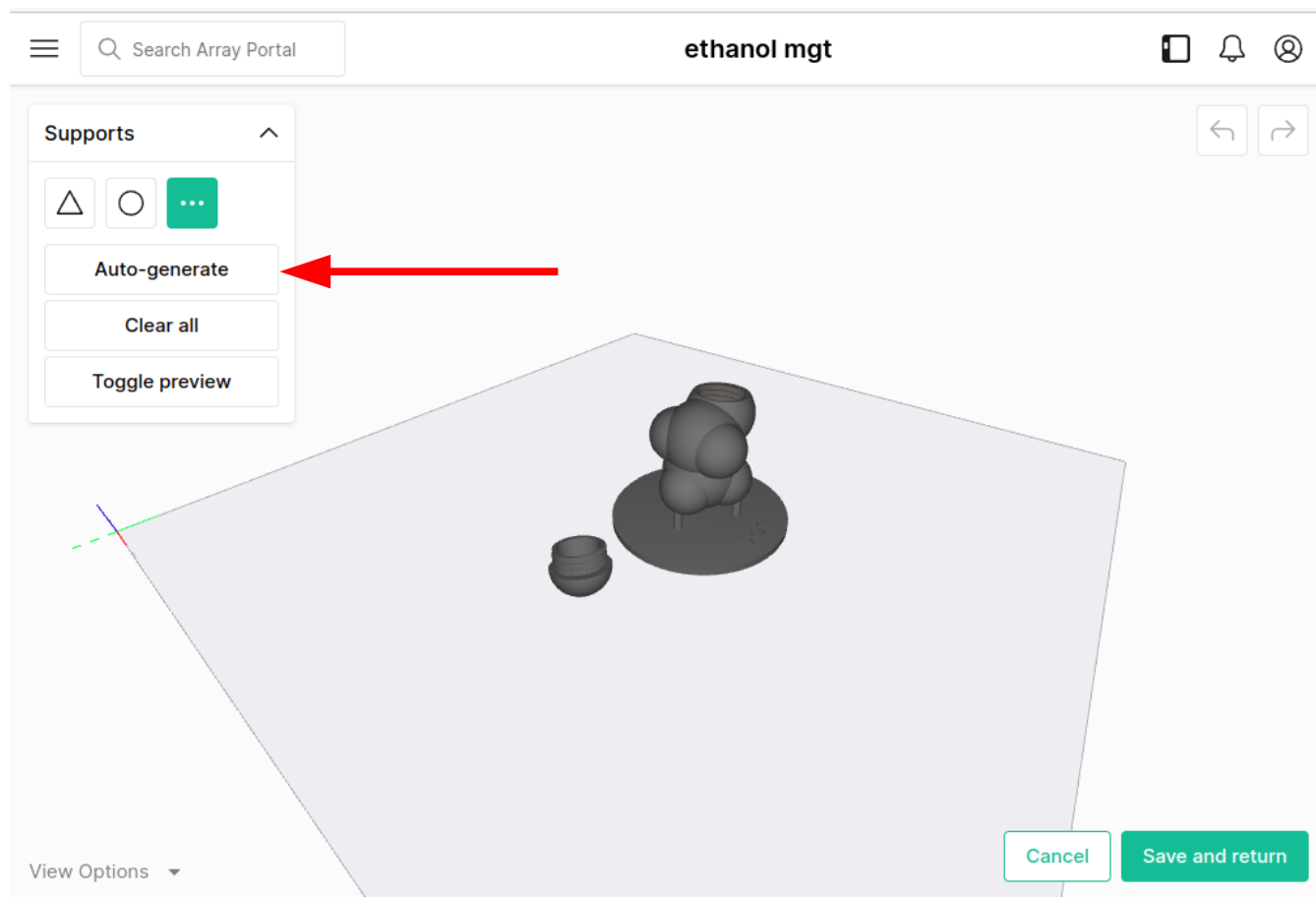
# Click on “Lay face to bed”



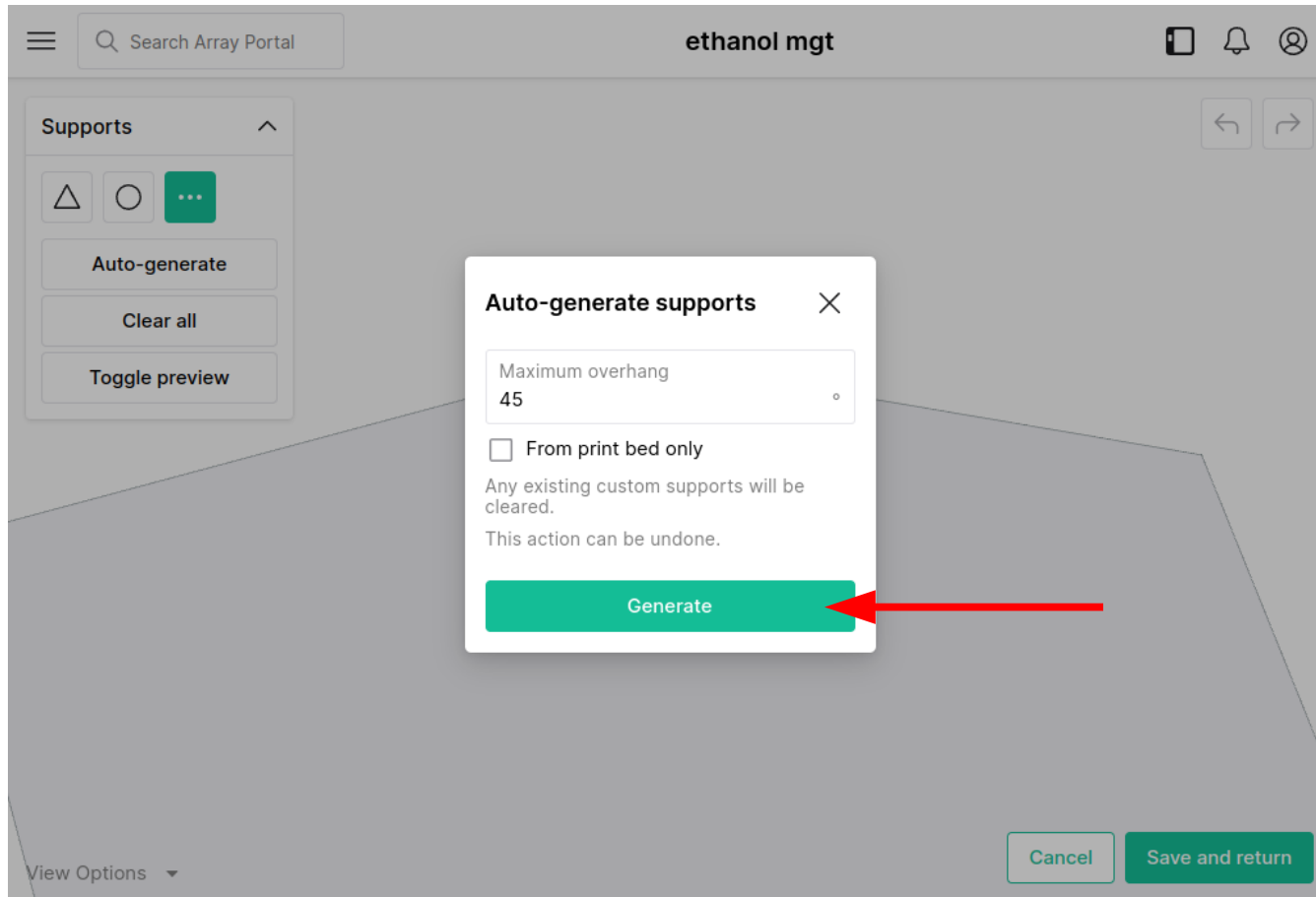
# Click on “Custom supports...”



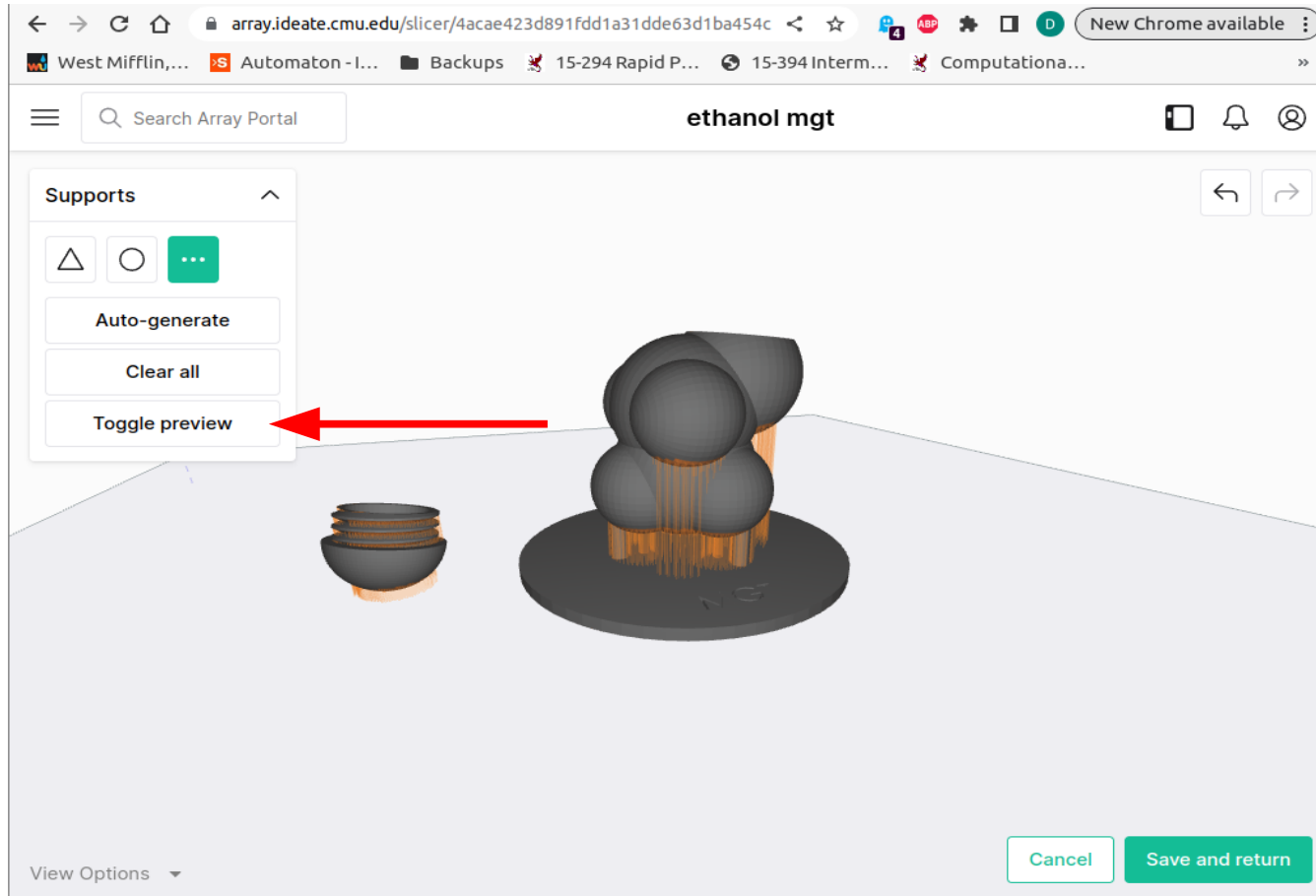
# Click on “Auto-generate”



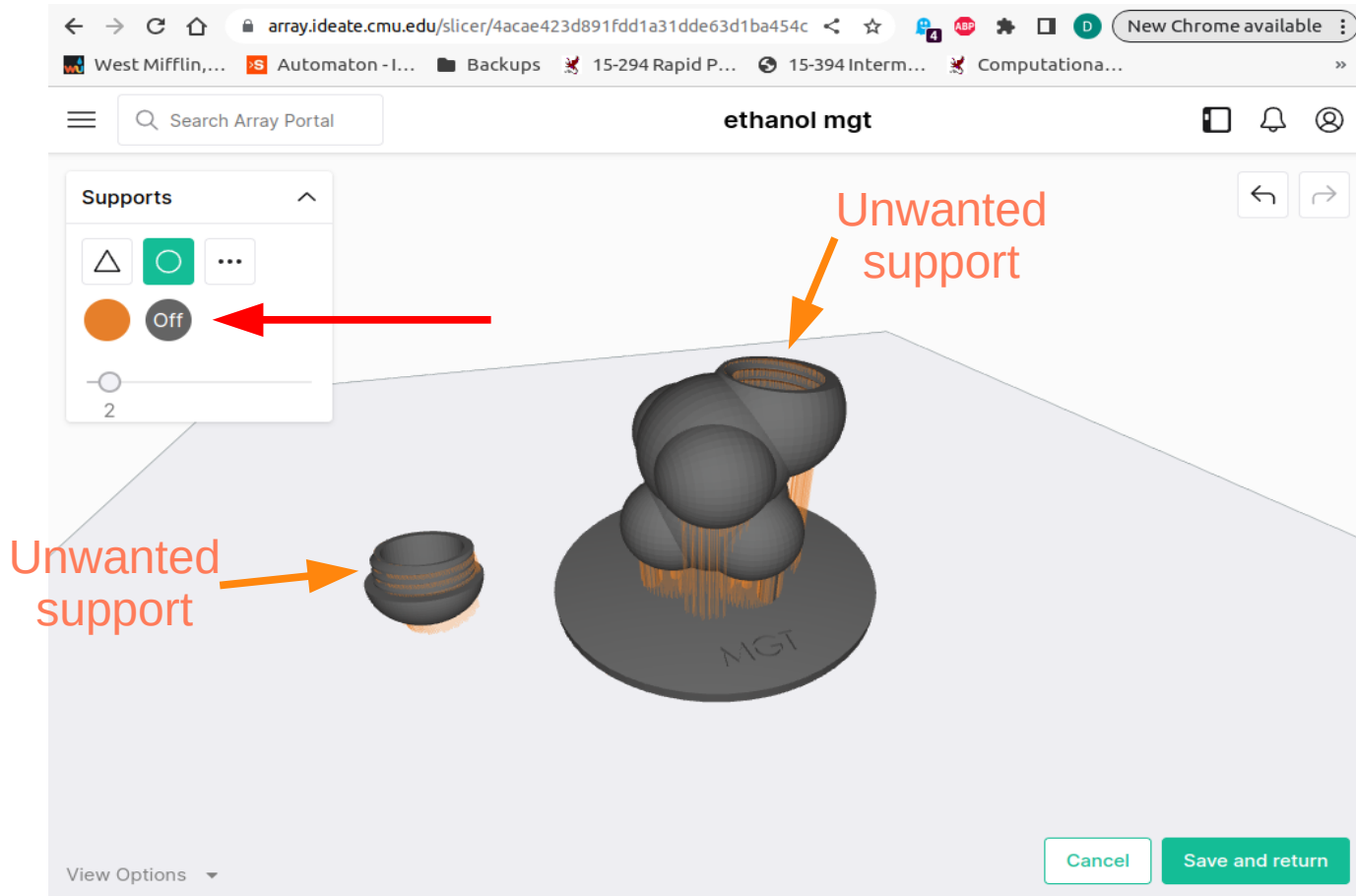
# Click on “Generate”



# Click on “Toggle preview”

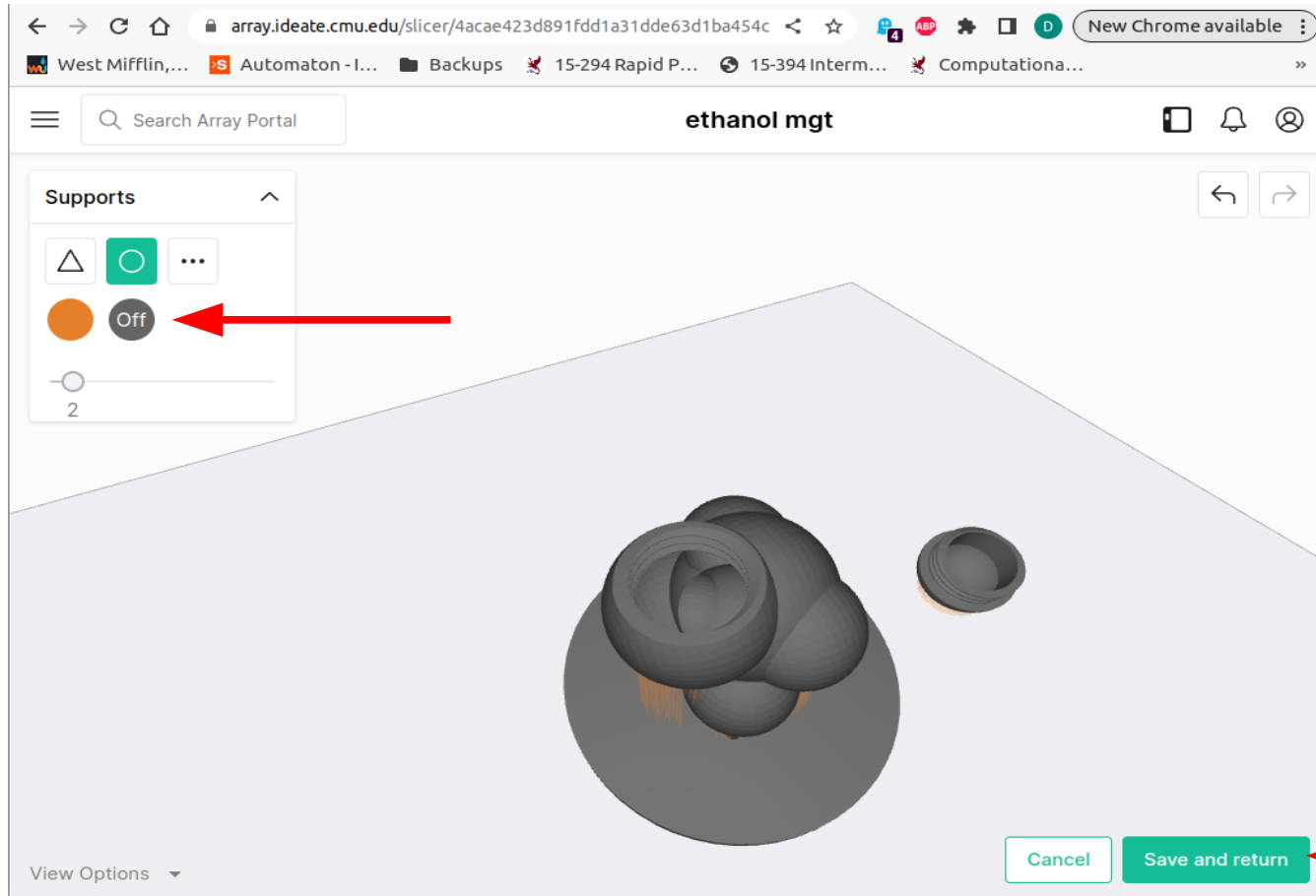


# Set brush to "Off"

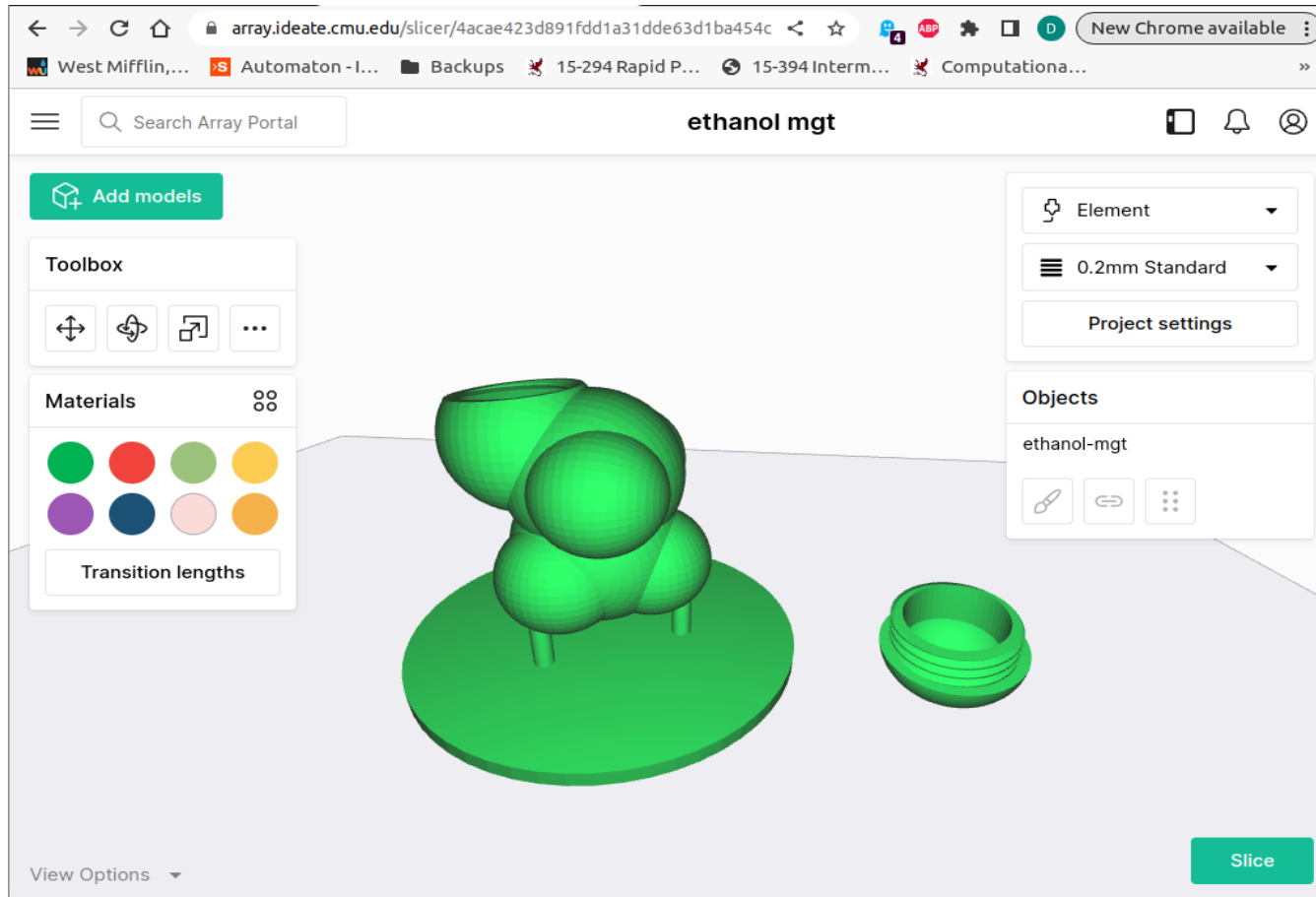




# Click and drag to erase unwanted support (need clean threads)



# Click on “Slice”



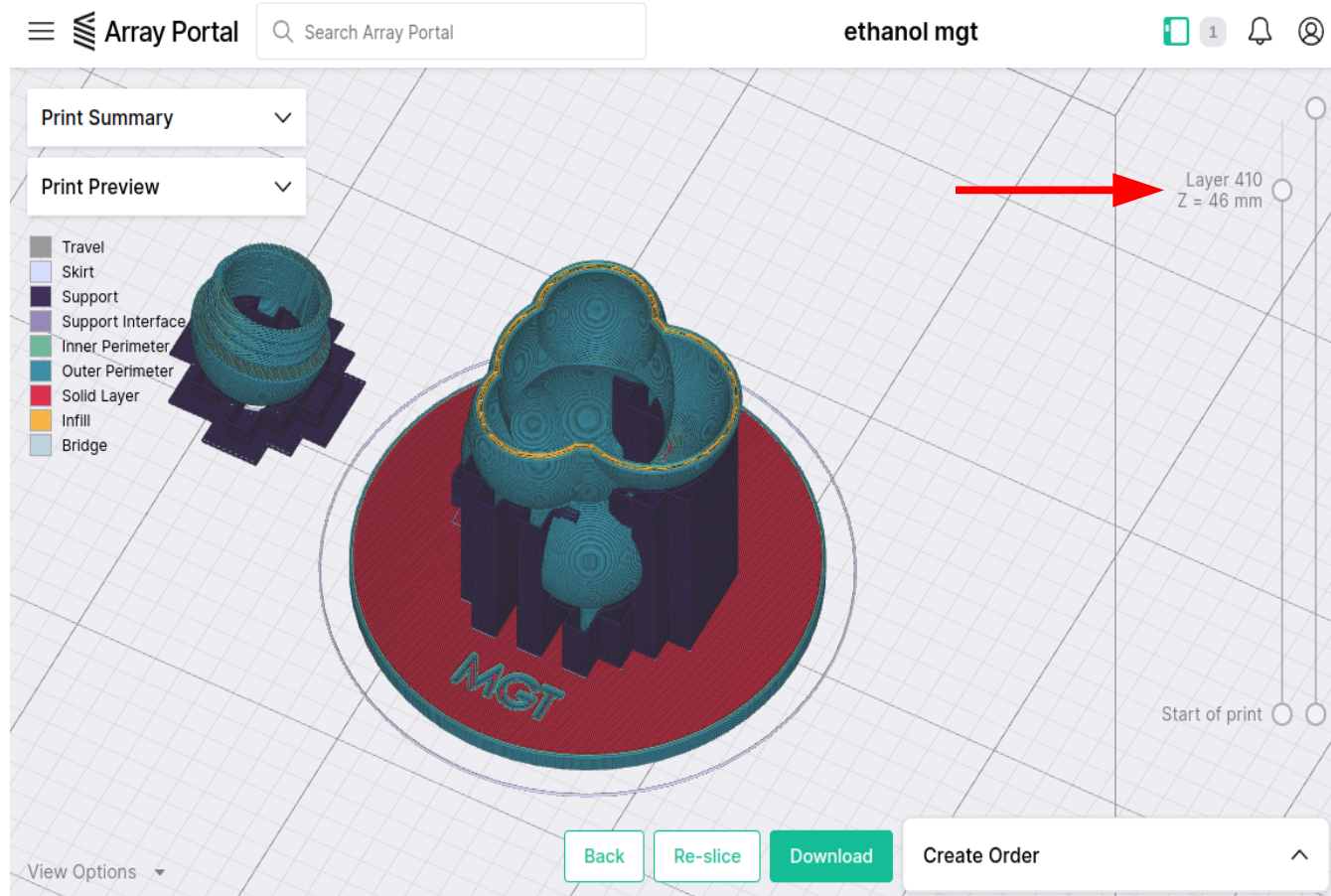
# Click on “Send to Array”

The screenshot displays the IDEATe Slicer web interface. At the top, the browser address bar shows the URL `array.ideate.cmu.edu/slicer/4acae423d891fdd1a31dde63d1ba454c`. The page title is "ethanol mgt". On the left, a "Print Summary" panel lists: Size: 81.3 × 120.1 × 58.9 mm, Time: 3 hr 3 min, Cost: \$1.24, and Filament Length: 11.05 m. Below it is a "Print Preview" panel with a "Path type" dropdown and checkboxes for "Show travel movement", "Show retract points", and "Show restart points". A legend at the bottom left identifies print elements: Travel, Skirt, Support, Support interface, Inner Perimeter, Outer Perimeter, Solid Layer, Infill, and Bridge. The central 3D view shows a blue and red printed part on a bed. On the right, a "Create Order" dialog box is open, containing a dropdown for "IDEATe Array: 1", an "Order Name" field with "ethanol mgt", a "Quantity" field with "1", and a "Bed Type" dropdown with "Type I". A green "Send to Array" button is located at the bottom right of the dialog, with a red arrow pointing to it. The top right corner of the interface shows "Layer 474" and "Z = 58.8 mm".

# Click on “Send to Array”

The screenshot displays the 'ethanol mgt' software interface. At the top, there is a search bar labeled 'Search Array Portal' and the title 'ethanol mgt'. On the right side of the top bar, there are icons for a mobile device, a notification bell, and a user profile. Below the top bar, on the left, there is a legend with color-coded categories: Travel (grey), Skirt (light blue), Support (dark blue), Support Interface (purple), Inner Perimeter (green), Outer Perimeter (teal), Solid Layer (red), Infill (yellow), and Bridge (light blue). The main area shows a 3D model of a printed part with a red solid layer and a teal outer perimeter. A white modal window is centered on the screen with the title 'Order received' and the text 'Array has received and queued this order.' It contains two buttons: 'Close' and 'Go to device'. On the right side, there is a 'Create Order' panel with a dropdown menu set to 'IDeATe Array: 1'. Below this, there are input fields for 'Order Name' (filled with 'ethanol mgt'), 'Quantity' (filled with '1'), and 'Bed Type' (filled with 'Type I'). At the bottom of this panel is a green button labeled 'Send to Array', which is pointed to by a red arrow. At the bottom of the main interface, there are buttons for 'Back', 'Re-slice', and 'Download', and a 'View Options' dropdown.

# Use Slider to View Layers



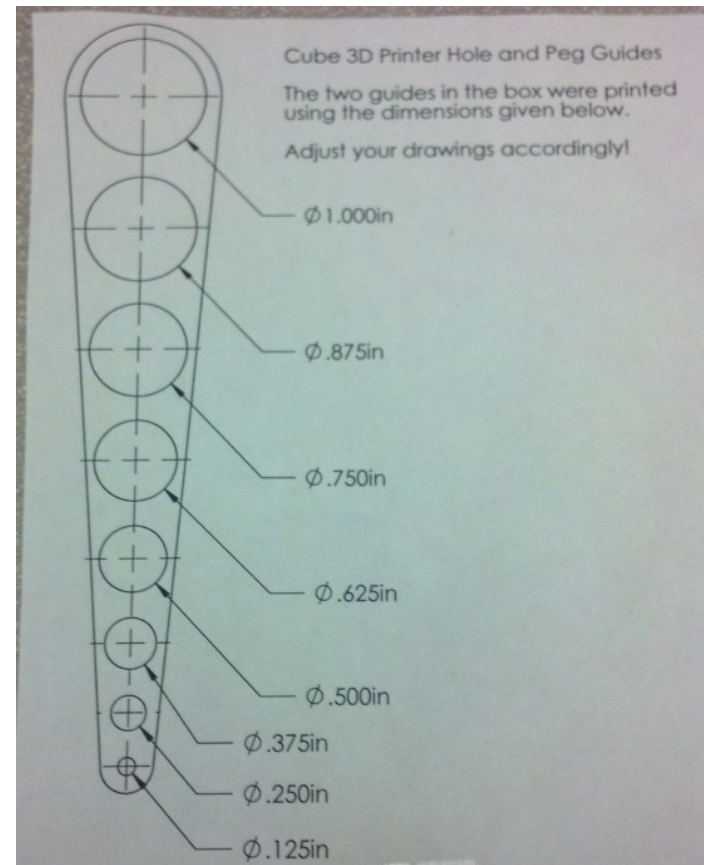
# Post-Processing Steps

- Snap off any supports or raft.
  - A pliers works well.
- Sanding or filing might also be helpful.
- Machining? Painting? Gluing? Fake fur?
  - It's up to you!



# Test Object (Mike Taylor)

- Compare requested size vs. actual.



# Design Rules

- Shafts will be slightly **thicker** than intended.
- Holes will be **narrower** than intended.
- Do you want a 2.5 mm hole? On a 1st generation Cube:
  - Use 3.0 mm for a horizontal hole.
  - Use 3.7 mm for a vertical hole.
- Minimum widths for walls?

# When Things Go Wrong



# Alternative Printing Choices

- Objet printer in Larry Hayhurst's shop.
  - Finer resolution, smoother finish.
  - Can print dissolvable support material.
  - Pay by the cubic centimeter.
- Stereolithography facility at Pitt.
- Shapeways
  - High end 3D printing service; many materials. e.g., ceramics.
  - Library of models and applications.
  - 8 day turn-around; fast shipping.