Printing Algorithmic Objects
Julia Sets, DLA, Fluids

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Overview

The Julia Set

Diffusion-Limited Aggregation

Molecules

Computational Fluid Dynamics

Best Technology For Fractals?

- For home: FDM (low cost and easy)
  (I like the Printrbot Simple)

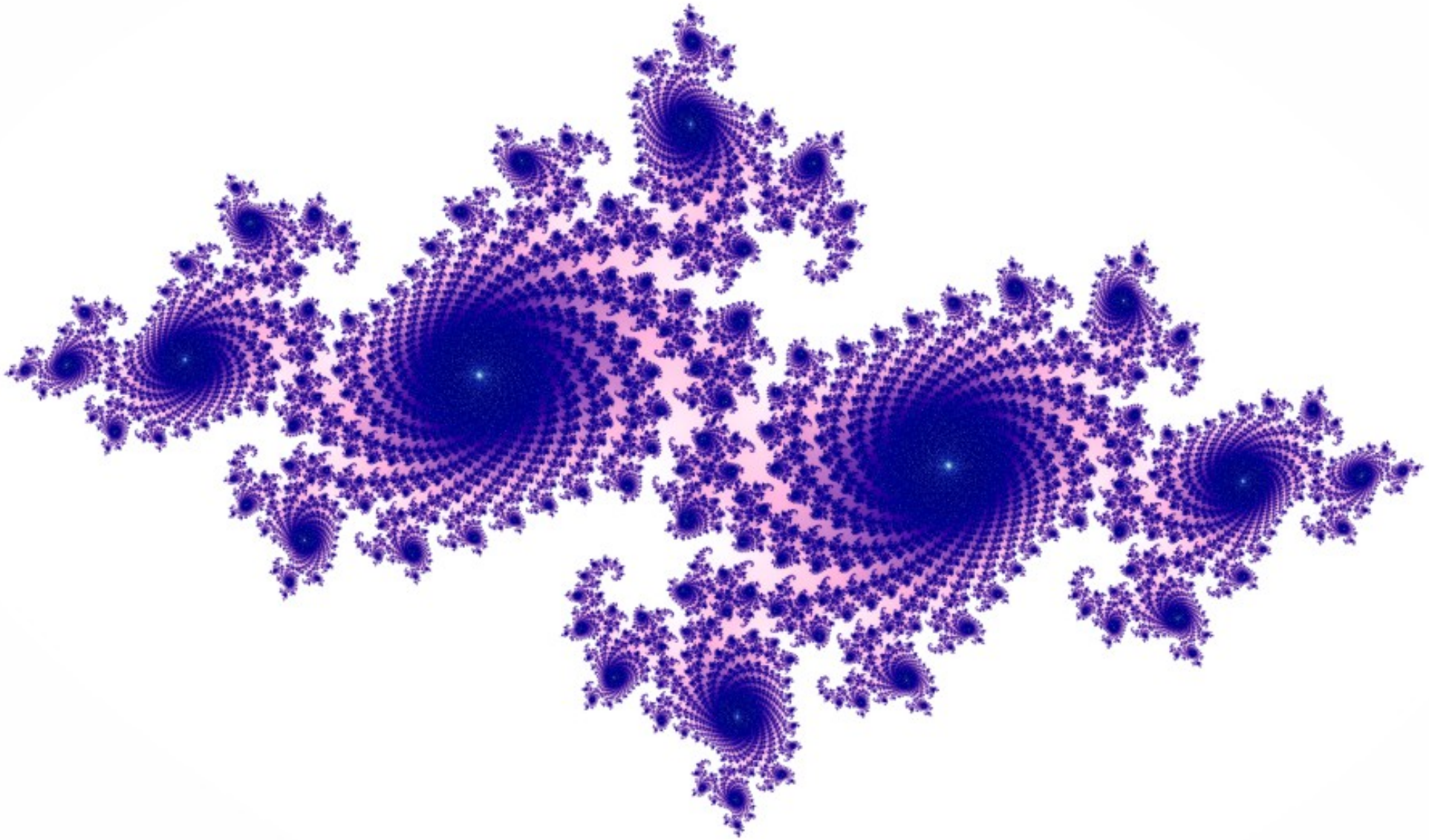
- For work: SLS or glued gypsum
  (ability to print craziest shapes/colors)

The Julia Set

The Julia Set

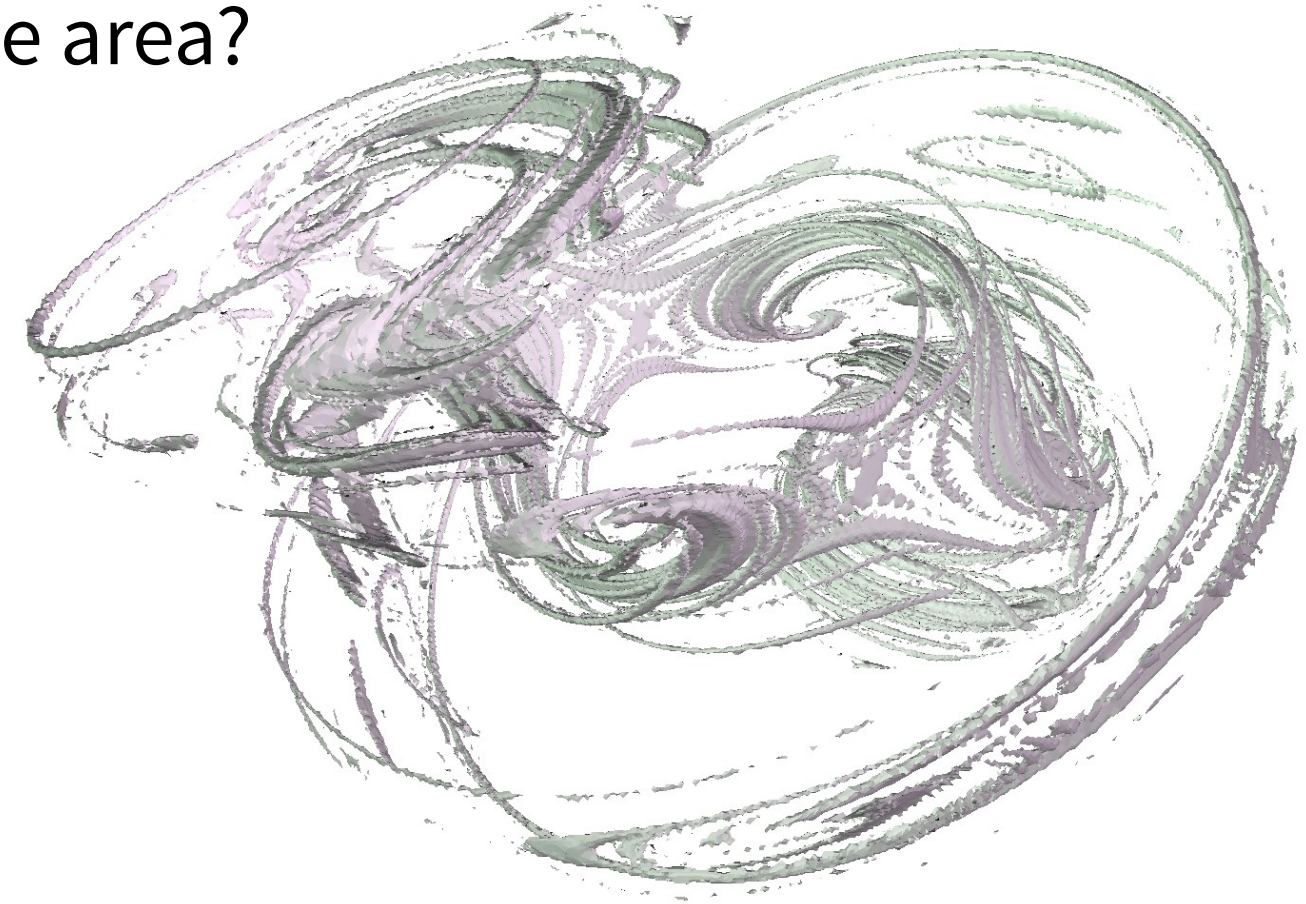
```
// for every i,j,k in 3D volume, do

cnt = 0; z1[] = {x,y,z,0.0}  // z1 is f(i,j,k)

while (forever)

  z0[] = z1[]

  z1[0] = z0[0]*z0[0] – z0[1]*z0[1]
        - z0[2]*z0[2] - z0[3]*z0[3] + julia[0]
  z1[1] = 2.0*z0[0]*z0[1] + julia[1]
  z1[2] = 2.0*z0[0]*z0[2] + julia[2]
  z1[3] = 2.0*z0[0]*z0[3] + julia[3]

  if (VecMag(z1) > cutoff) break
  if (++cnt > maxIters) break

end

out[i][j][k] = (cnt > maxIters) ? 1.0 : 0.0
```

Julia Set in 2D



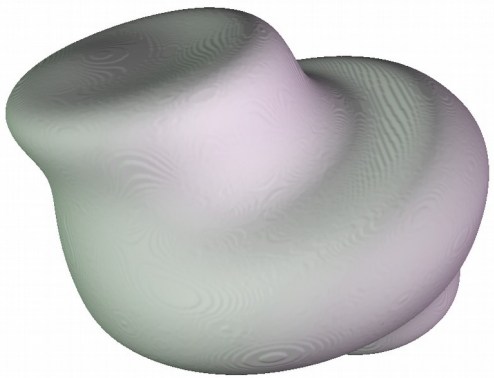
Problem: Infinite Detail

How do we manifest something with infinite surface area?

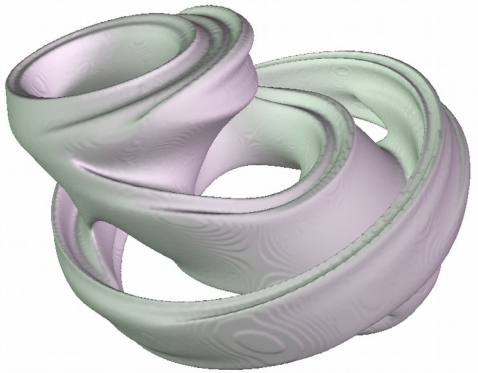


With cutoff ~4, any maxIters > 20 gives too much detail!

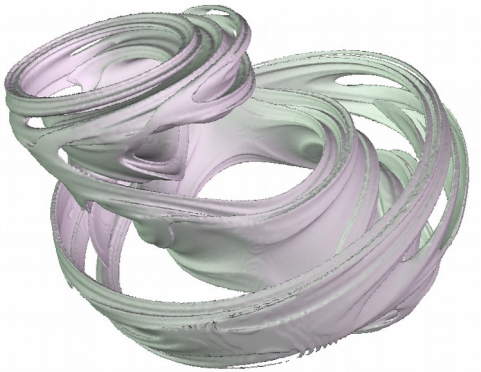
Allowed Iterations vs. Shape



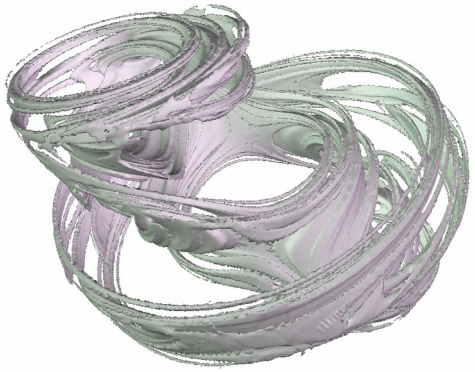
4 iters



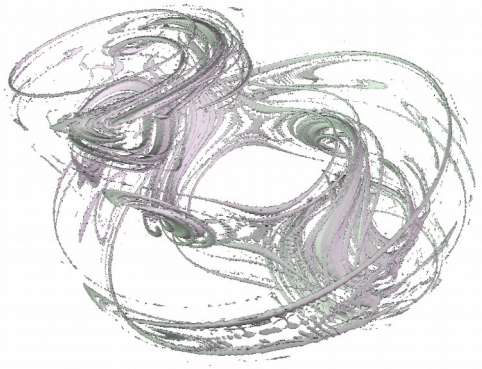
8 iters



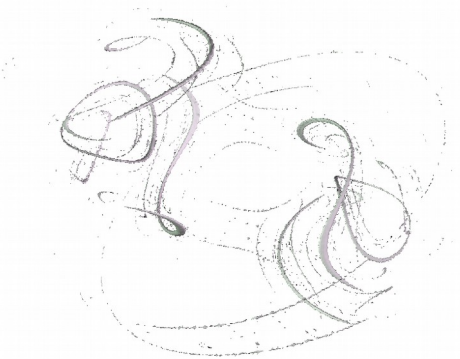
12 iters



16 iters



24 iters



32 iters

Julia Sets with x=-0.4 y=0.4 z=0 w=0.6

Julia Set in 3D

Julia Set in 3D

Julia Set in 3D

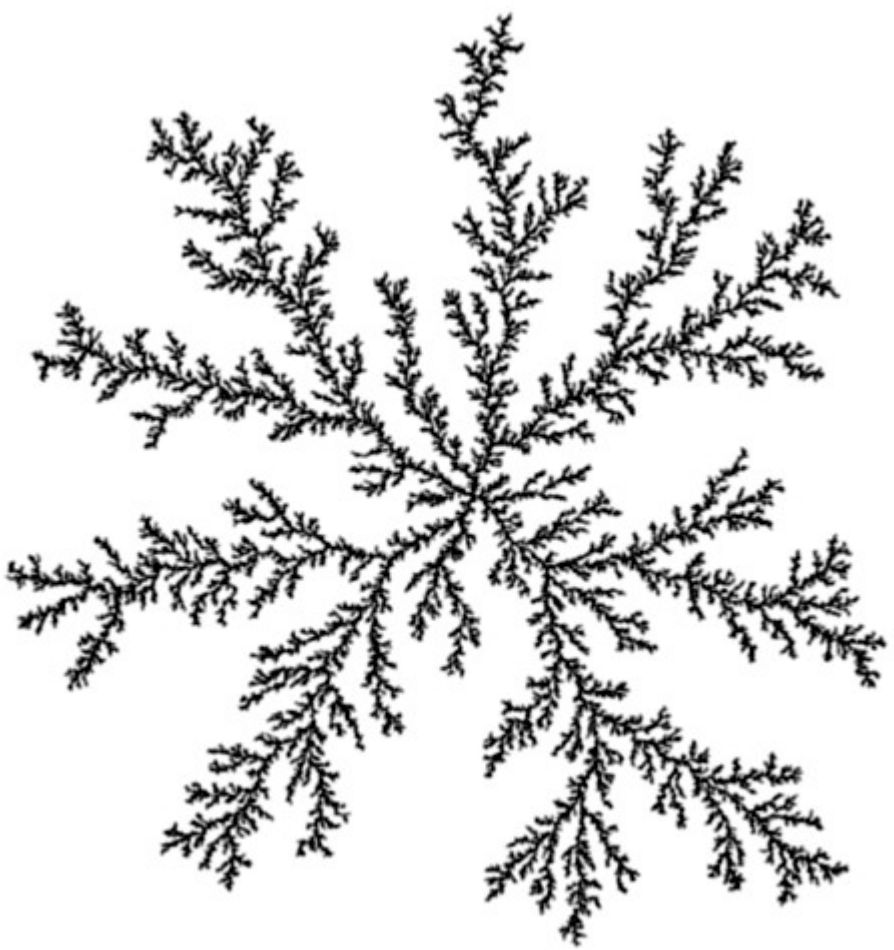
Diffusion-Limited Aggregation

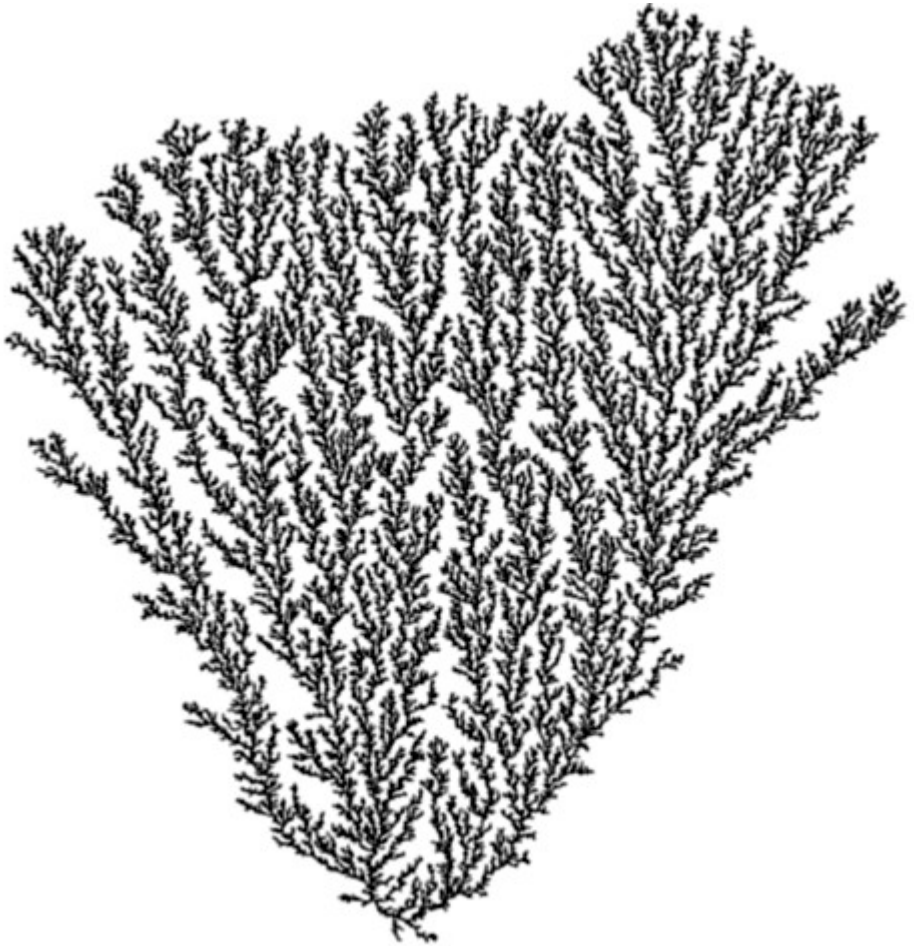
Diffusion-Limited Aggregation

T. Witten and L. Sander,
Physical Review B **27**, 5686-5697 (1983)

1. Begin with fixed particle at 0,0[,0]
2. Random-walk new particle until it
   contacts any fixed particle
3. Fix that particle at the contact pt
4. Goto 2.

DLA in 2D





http://markjstock.org/dla-nd/

DLA: Closing The Mesh

1. Start with DAG data

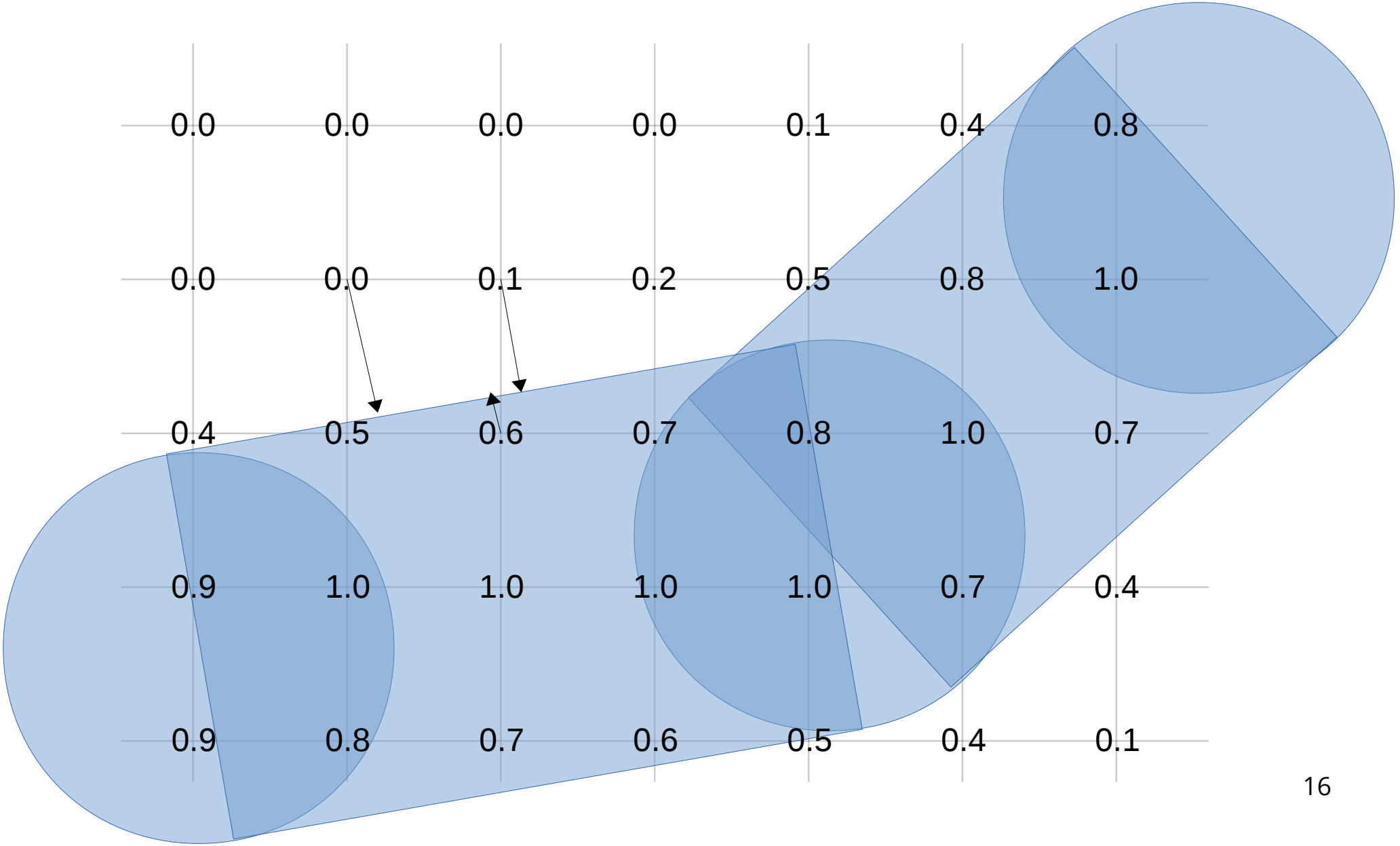
2. Calculate radius for each segment
   (try c*weight^(1/D))

3. Trim tips to reduce complexity

4. Convert to rasterized (voxel) grid*

5. Isosurface to generate triangle mesh

DLA: 3D Rasterization



DLA: 3D Rasterization Tips

SLS (nylon) is the ~~best~~ only material

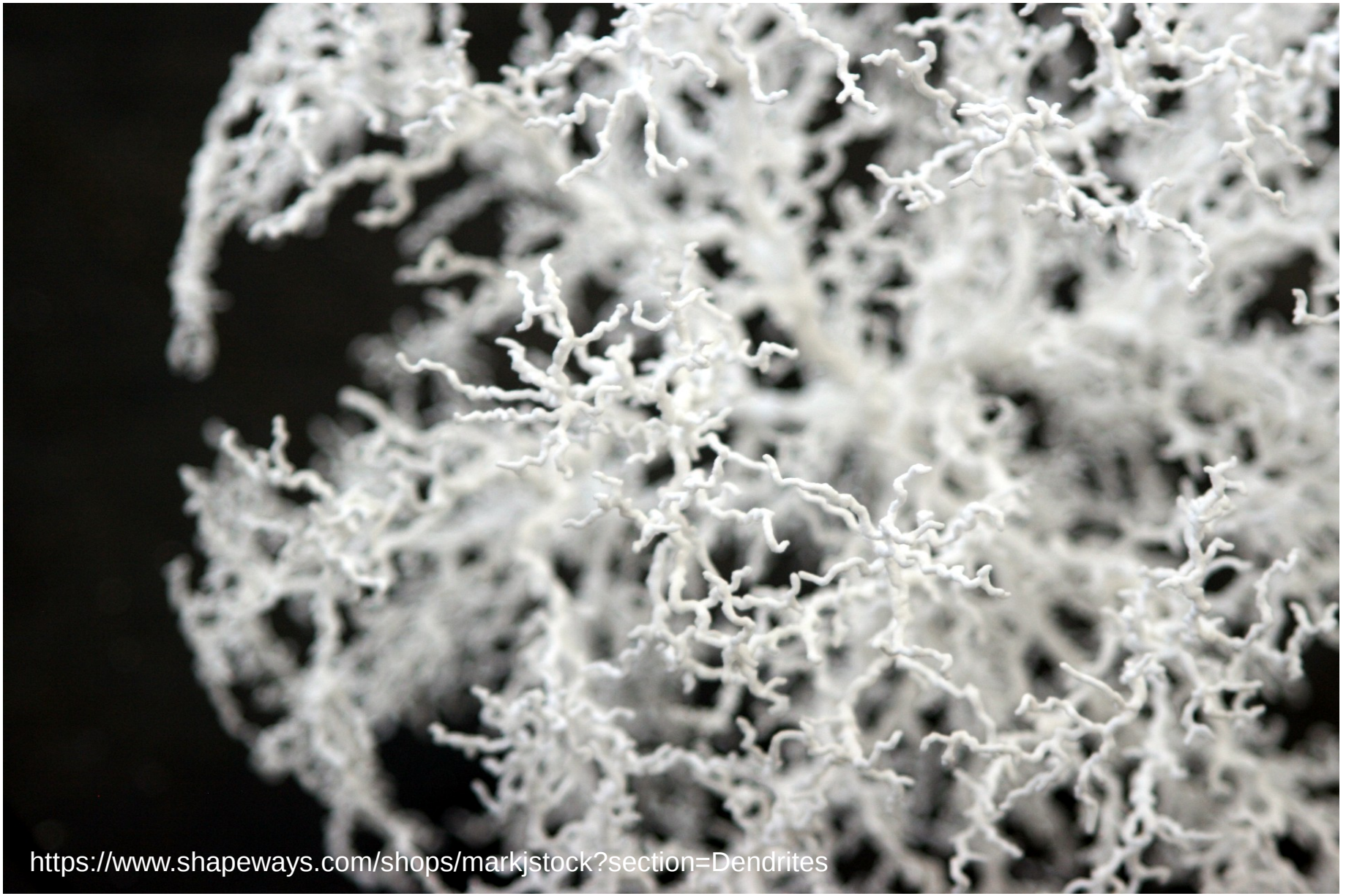
Keep cylinders >0.8 mm diameter

Have >3 voxels across narrowest geom

DLA in 3D

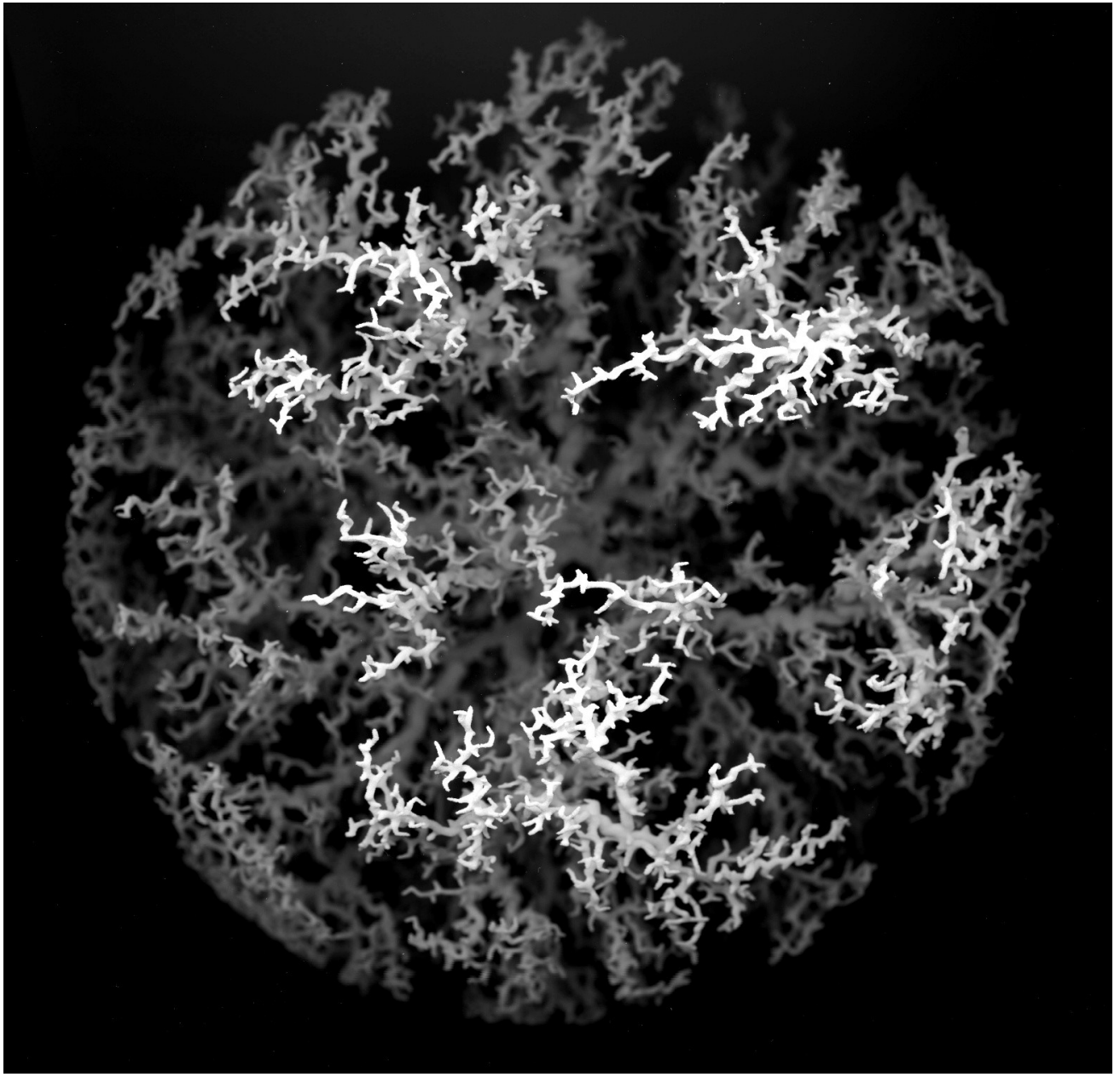

https://www.shapeways.com/shops/markjstock?section=Dendrites

DLA in 3D



https://www.shapeways.com/shops/markjstock?section=Dendrites

DLA in 3D

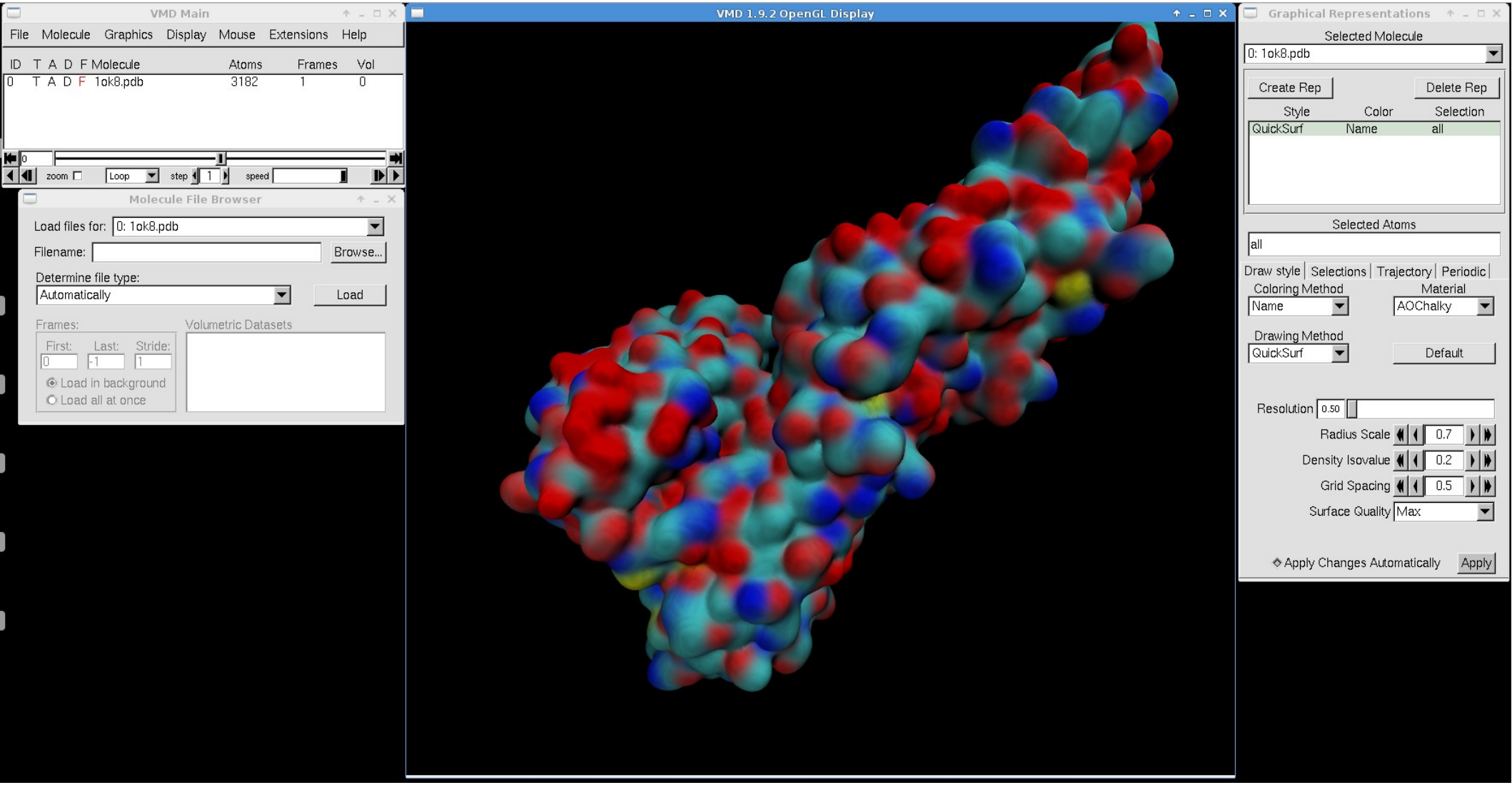


Full-Color Molecules

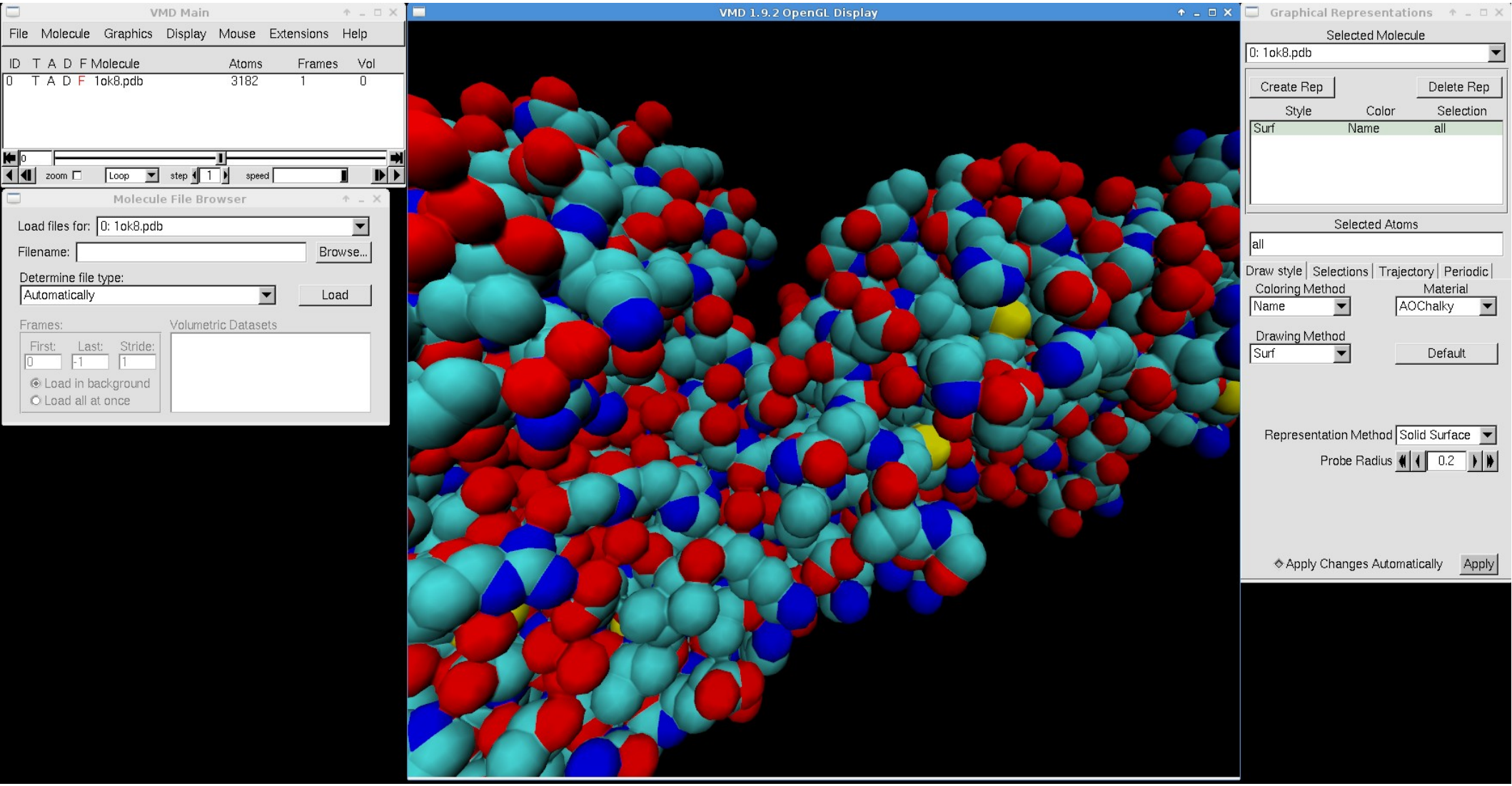
Full-Color Molecules

1. Download and install VMD
   http://www.ks.uiuc.edu/Development/Download/download.cgi?PackageName=VMD
2. Download .pdb file for molecule and open
   http://www.nyu.edu/pages/mathmol/library/drugs/
   http://www.rcsb.org/pdb/home/home.do
3. Set Graphics->Representations to Surf/Quicksurf
4. Set Display->Axes->Off
5. File->Render->X3D
6. Some repair may be necessary

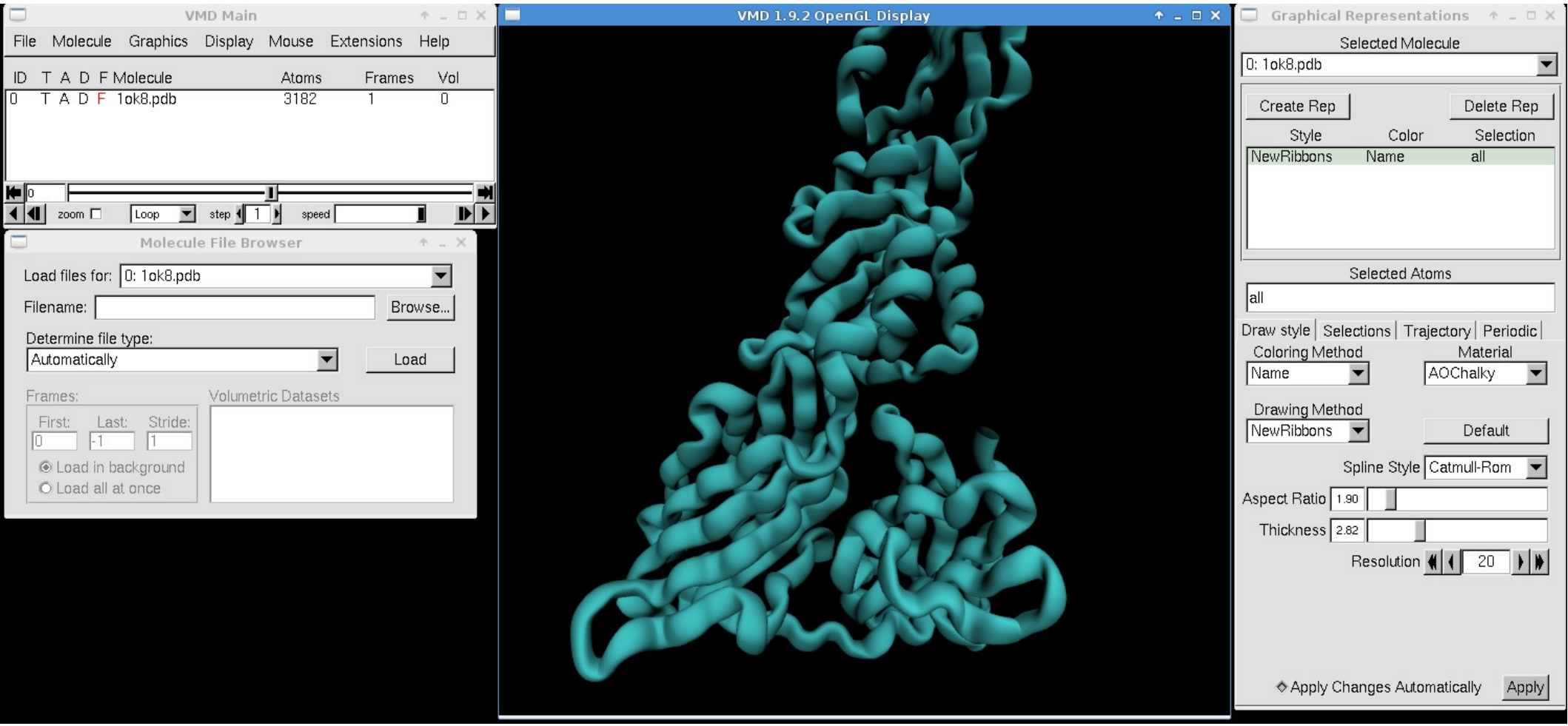
Dengue Virus (QuickSurf)



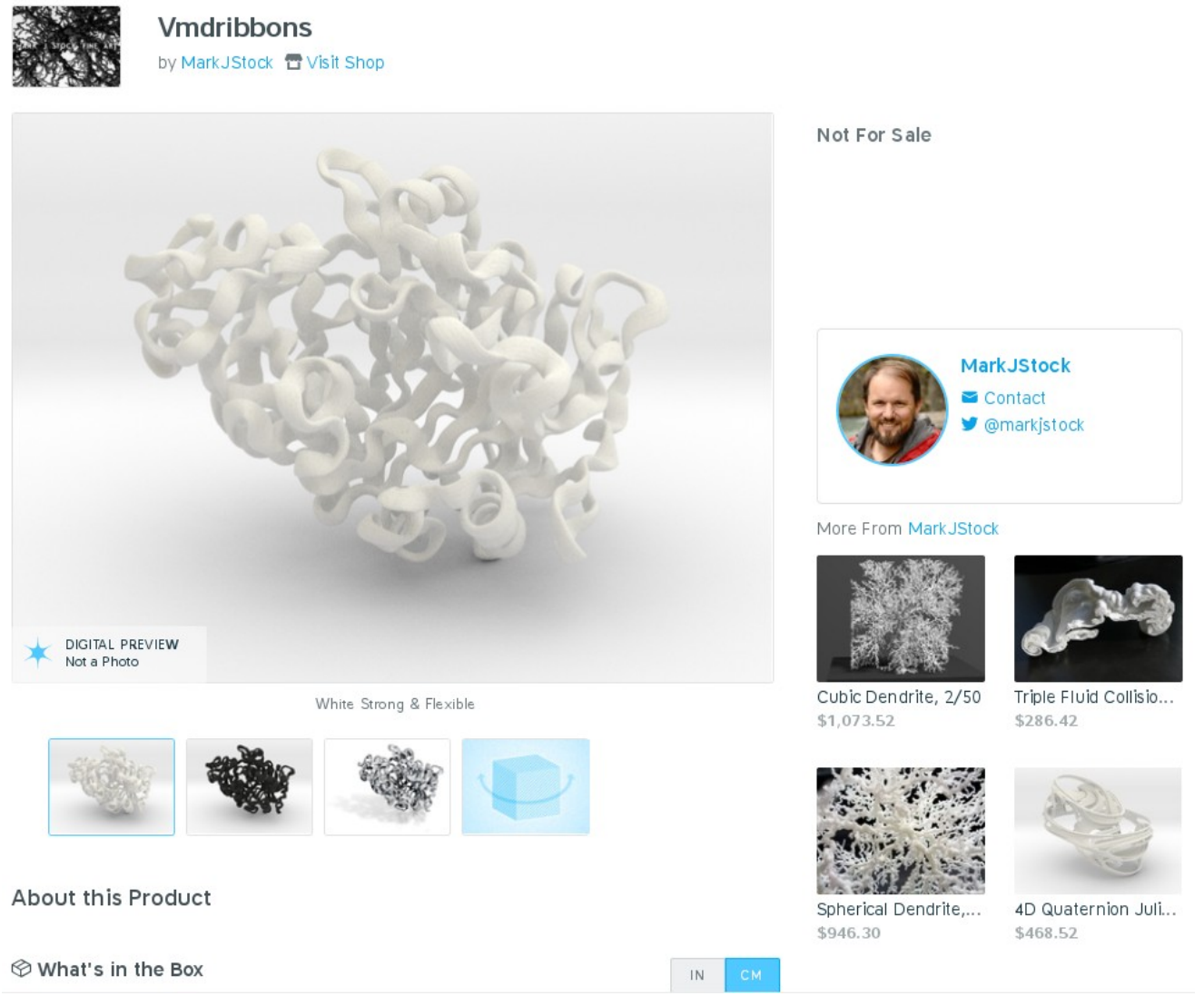
Dengue Virus (Surf)



Dengue Virus (Ribbons)



Complex Biomolecule (Ribbons)



Computational Fluid Dynamics

Computational Fluid Dynamics

2D? Easy to compute, can print heightfield
3D? Hard to compute, but what to print?

Solution: Drop a dimension: use lines and surfaces

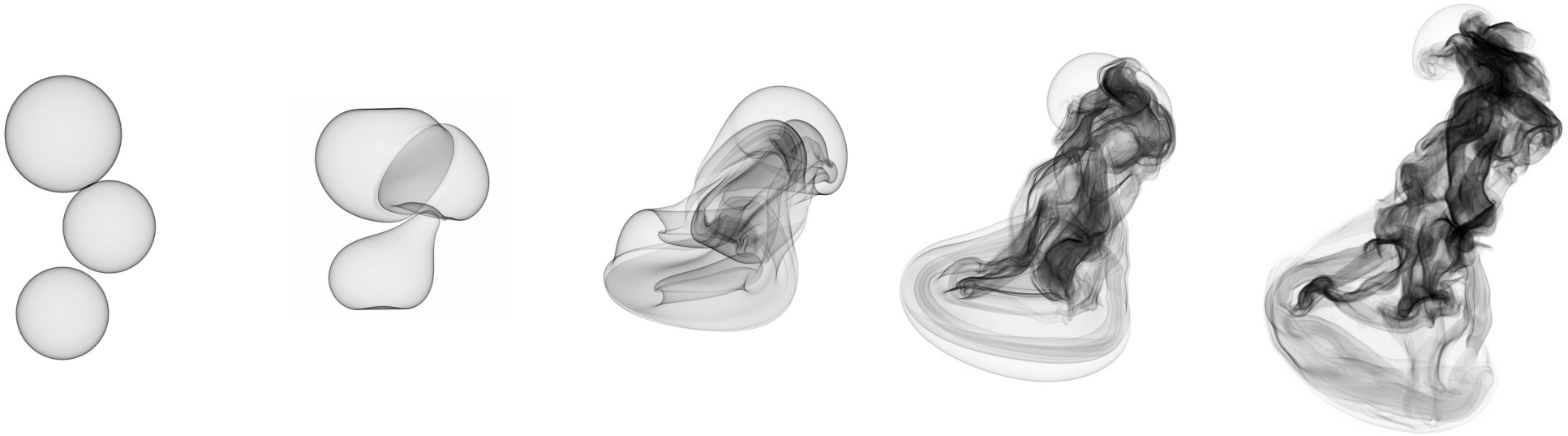
2D Simulation to 3D Print

De-Volumizing 3D Flows

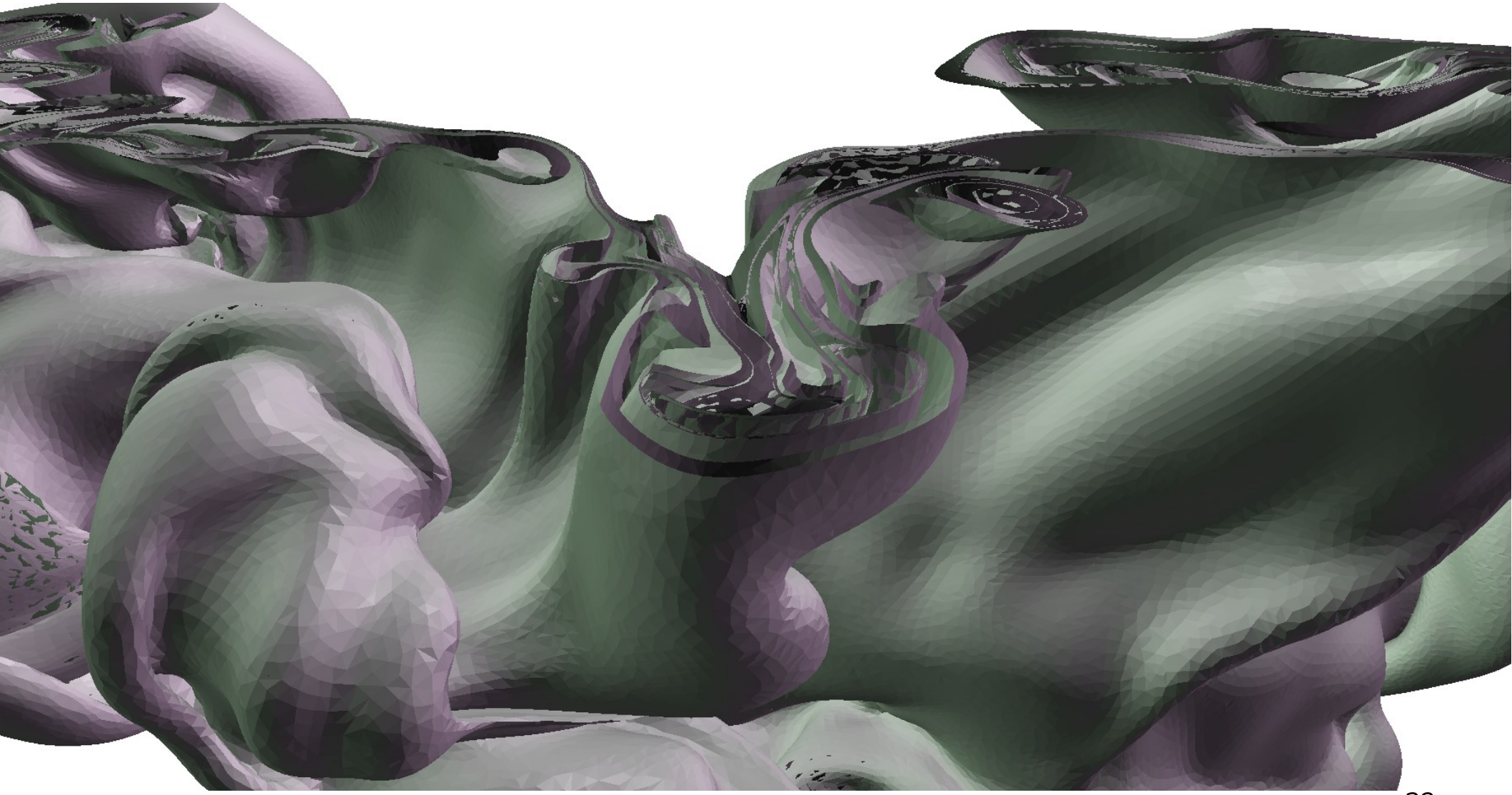
- Computational elements are lines and surfaces
- Tracked particles become lines (streamlines)
- Tracked lines become surfaces (streamsurface)

Re-volumize for printing with voxel rasterization

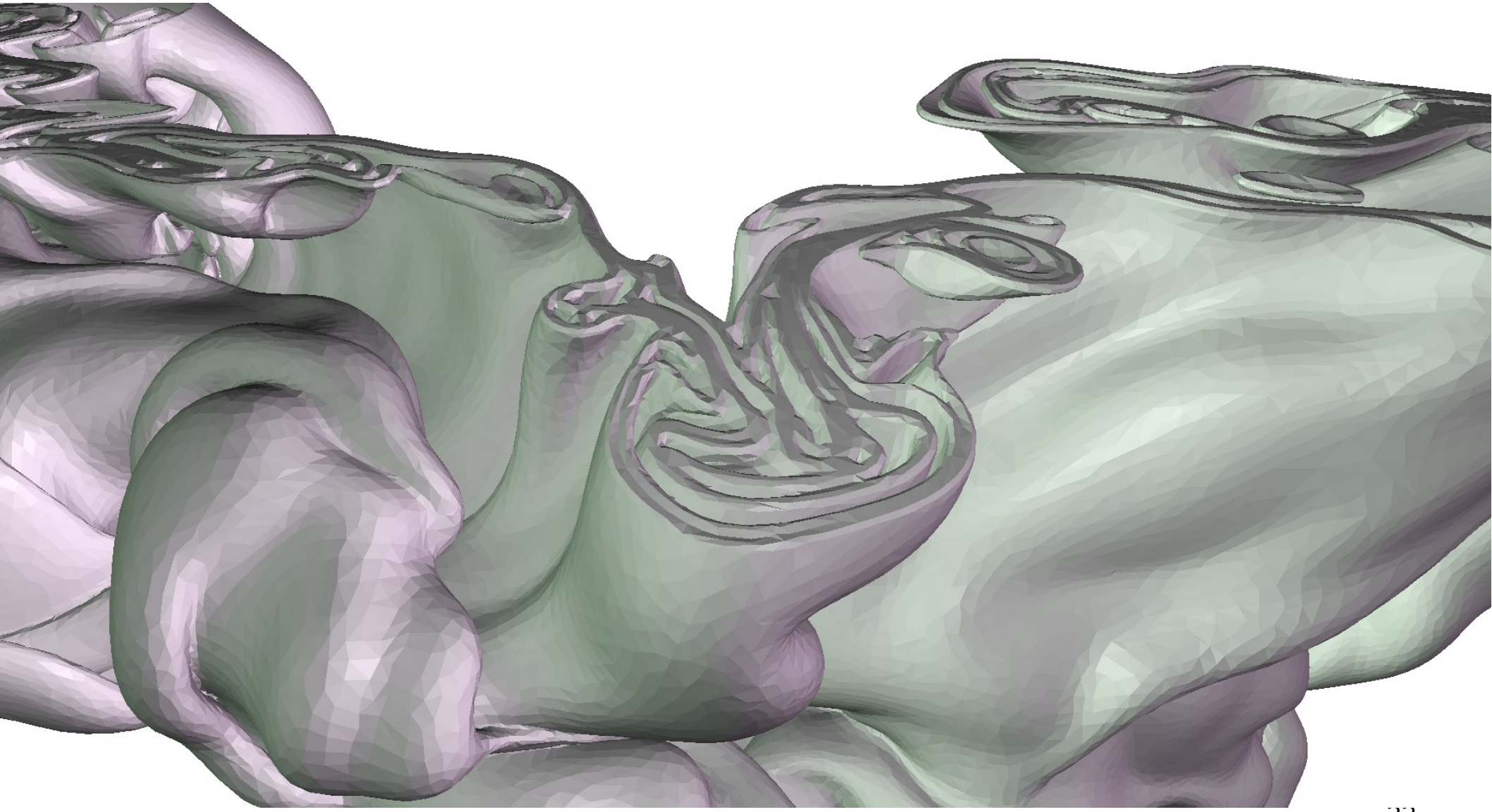
Vortex Sheet Simulations



Vortex Sheet (Raw)



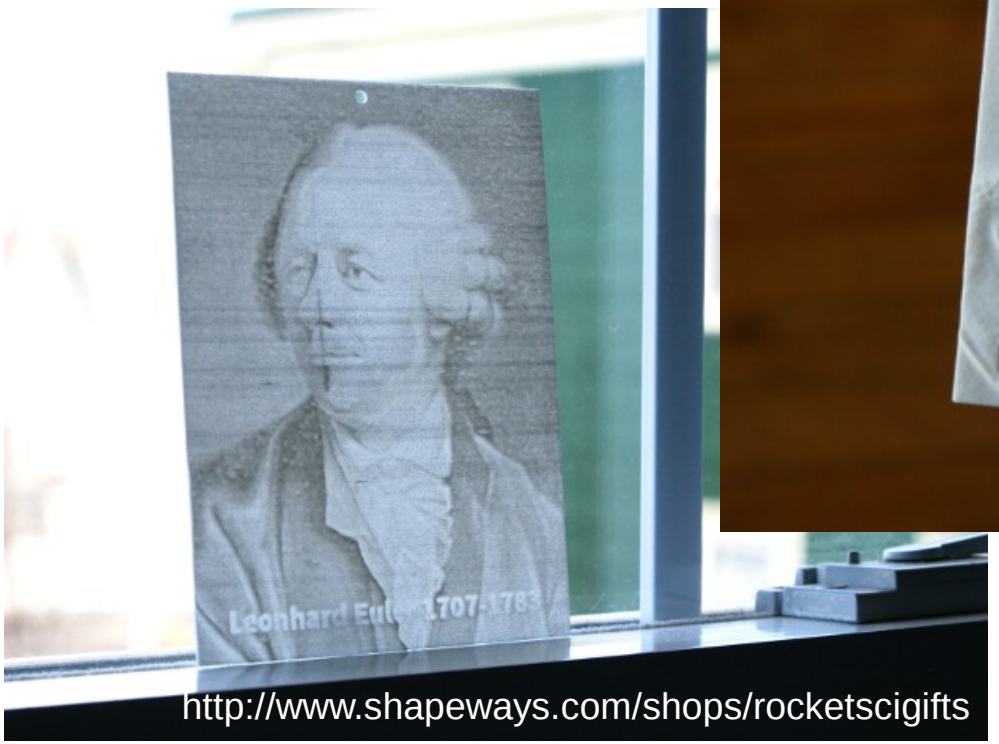
Vortex Sheet (Re-Volumized)



Vortex Sheet (In SLS Nylon)

Vortex Sheet (In SLS Nylon)

Lithophane



Make the back flat and the top bumpy!

Summary

- 3D printing is easier & cheap now
- Smooth away the fine detail, either via algorithm or post-process
- Use online tools for modeling, sharing
  (Meshlab, Autodesk 123D Make, Shapeways...)

Thank You

markjstock

[.com|.org|@gmail|twitter|vimeo|shapeways]