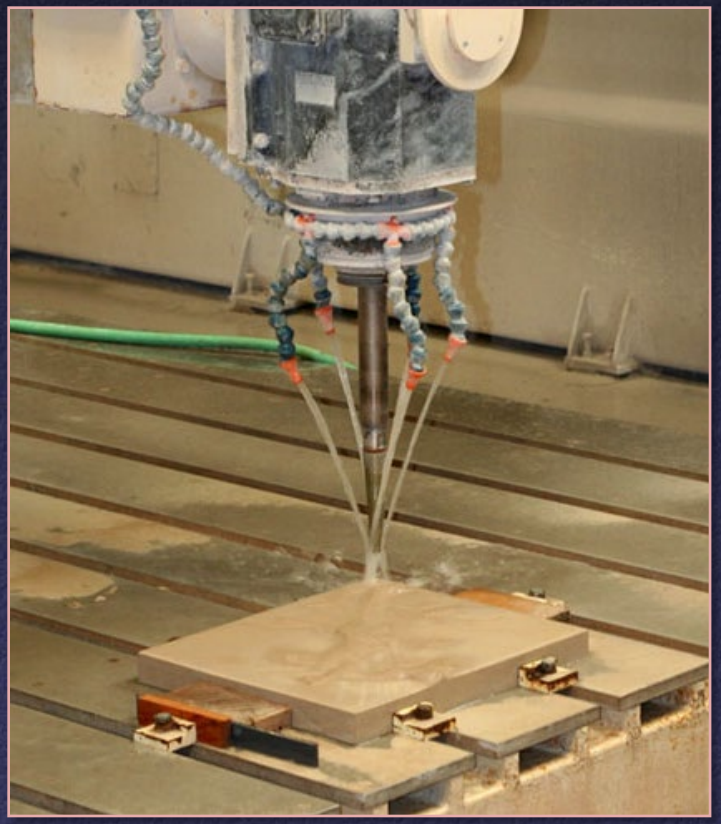
Computational Fabrication

Acknowledgments: some slides by Vladimirs Pankratovs and Tom Easton

Digital Fabrication Technologies

- Subtractive: computer-controlled milling
  - Materials: metal, wood, plastic, stone
  - Key parameter: # of axes
    - 3-axis machines can only produce height fields
    - 4- through 6-axis machines available: more flexible



Digital Fabrication Technologies

- Additive: "3D printing" of one slice at a time

3D Printing Pipeline

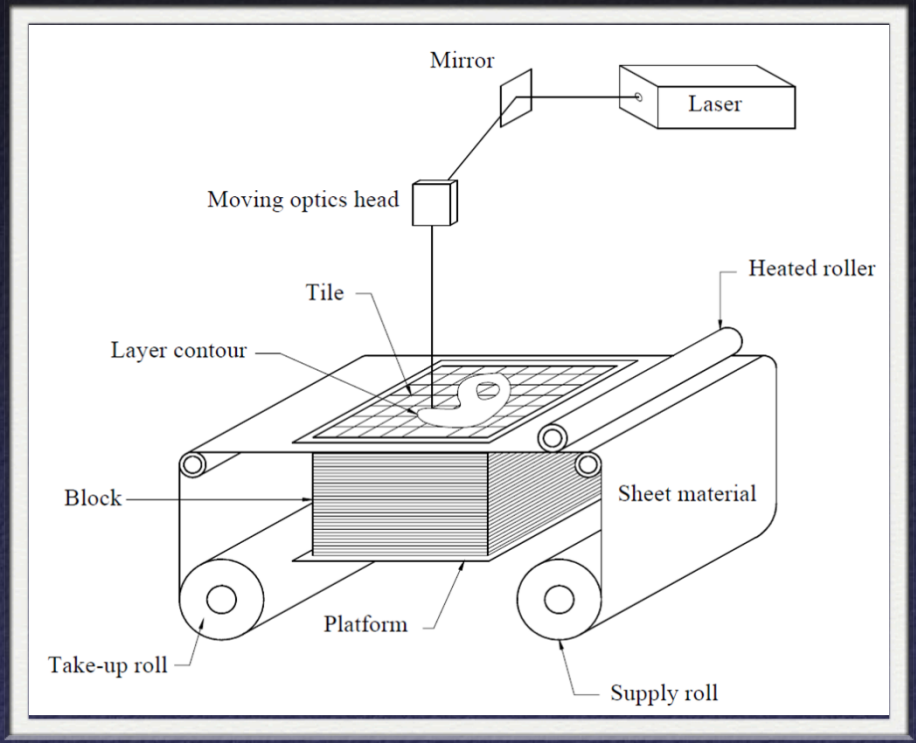
- Slice 3D model, build object layer by layer
  - Typically a few layers / mm, but >50 for some machines
- Slow: can take hours
  - But it is getting better—rapidly!

3D Printing Technologies

- Laminated object manufacturing
- Fused deposition modeling (FDM)
- Selective laser sintering (SLS)
- Stereolithography

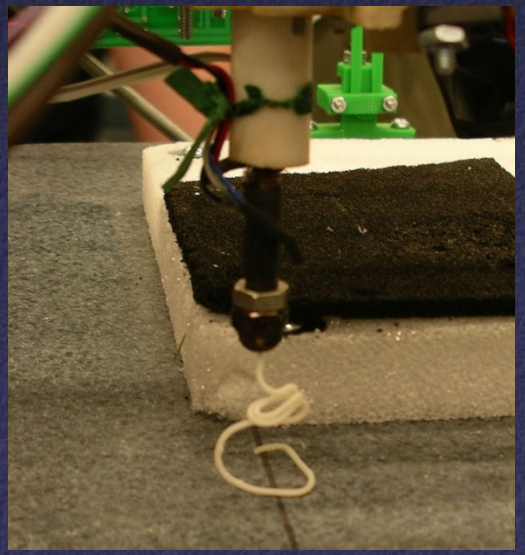
Laminated Object Manufacturing

- Cut thin layers of material (plastic, cardboard, etc.) with laser, mill, or knife
- Assembled by hand

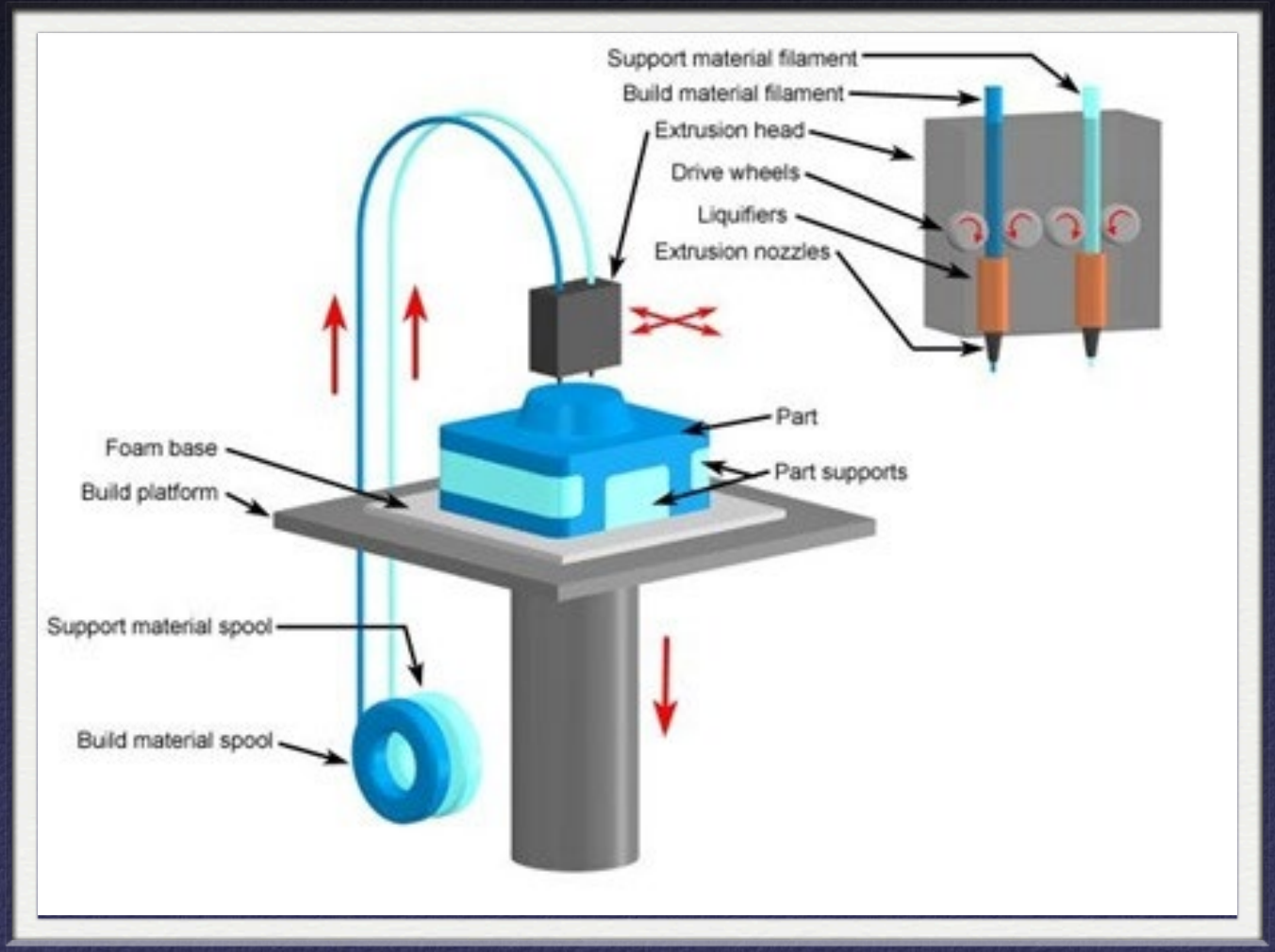


FDM

- Extrude a bead of semi-liquid material (heated plastic, plaster, wax, chocolate, etc.) to form solid layers



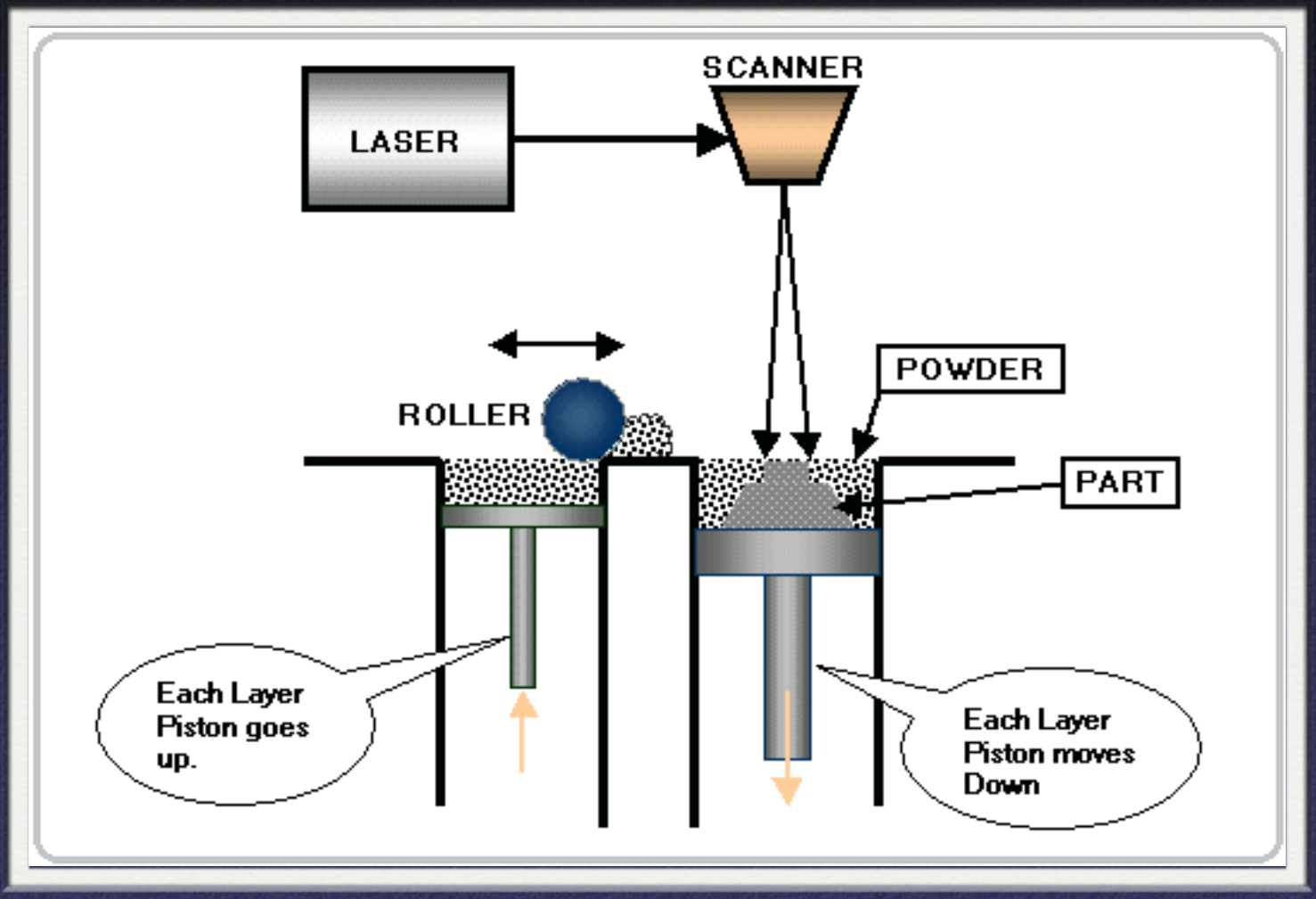
FDM


Support material filament
Build material filament
Extrusion head
Drive wheels
Liquifiers
Extrusion nozzles
Part
Part supports
Foam base
Build platform
Support material spool
Build material spool

SLS

- Form layer of small particles: plastic, metal, ceramic or glass powders
- Fuse (sinter) with high-power laser

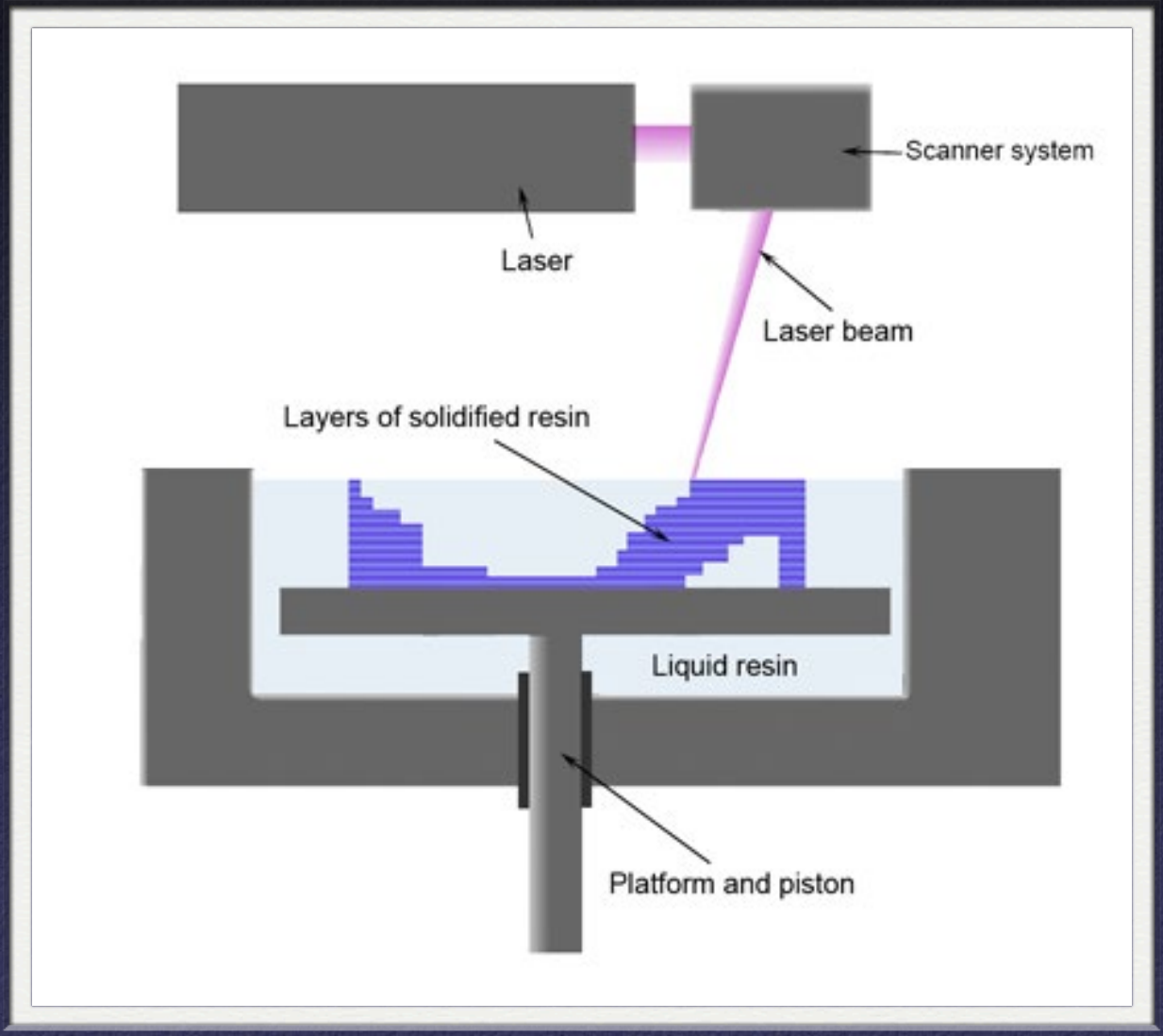
SLS


SCANNER
LASER
POWDER
ROLLER
PART
Each Layer
Piston goes
up.
Each Layer
Piston moves
Down

Stereolithography

- Tank of liquid resin
- Polymerize (harden) a layer at a time with UV laser

Stereolithography

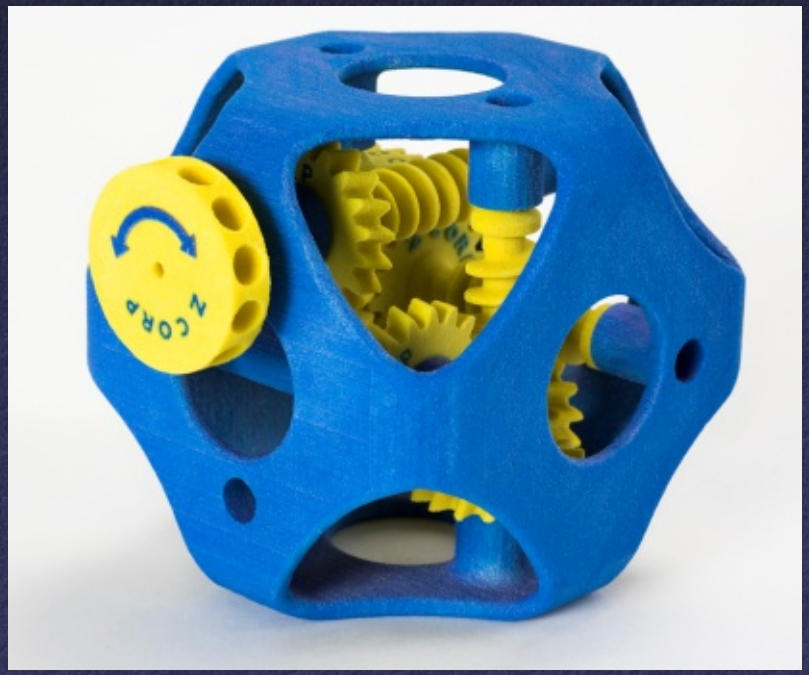


Variant: Objet Connex

- Variety of UV-curable materials deposited by “inkjet” heads

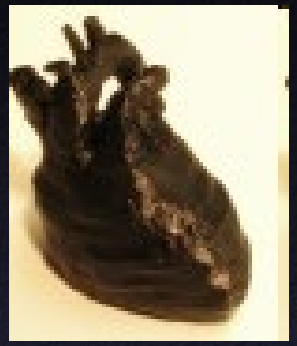
Variant: Z-Corporation

- Solid powder with binder deposited by "inkjet" heads




ThatsMyFace.com




Limitations

- Slow
- Expensive
  - Until recently, there were only industrial machines priced from $20k… High end at $500k+
- Surface layering visible
  - Often higher resolution within a layer than layer thickness (except for FDM)

But…

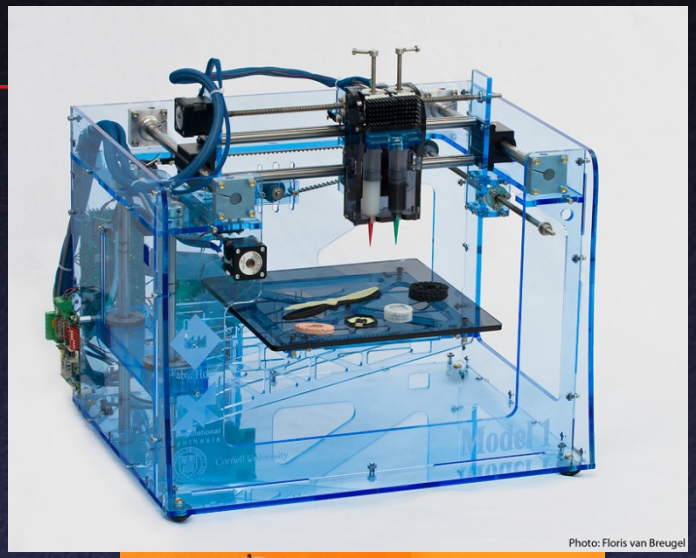
- Print shops are cropping up
  - E.g., Shapeways
- Specialized products
  - Christmas ornaments with your face
  - Masks
  - Artwork
  - Fetuses
    - "The London Ultrasound Centre in the UK offers the ability to take a 3D scan of your offspring - before birth - and produce a 3D print of the child. Actually, the 3D Print is simply used to create a mold for subsequent bronze casting. There's no official pricing on the Centre's website for this service, but according to the Daily Mail, it costs 1,200 pounds sterling (or around USD$1,800) and takes several weeks to deliver!"

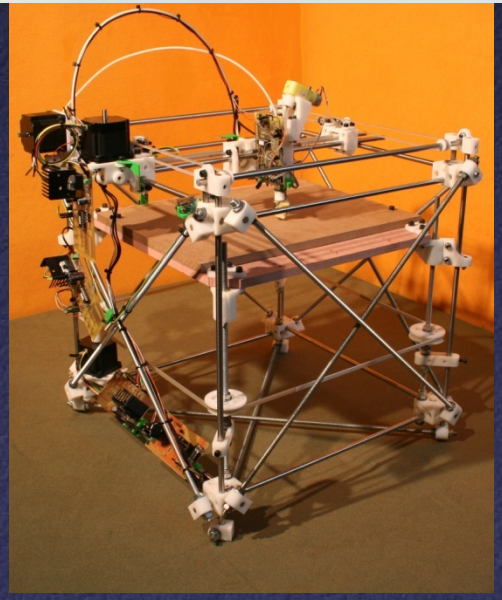
For the DIY Crowd

- MakerBot, Bits From Bytes, Fab@Home
  - A few thousand $$
- RepRap
  - Under $1,000 for parts

  (and it can print parts

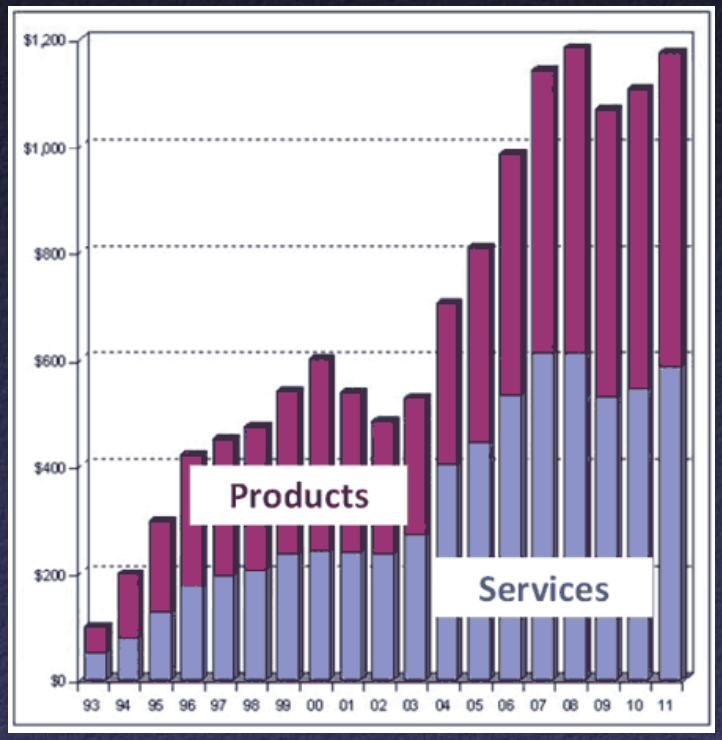
  for new machines!)





Where Is It Going?

- The low-end prices are (in constant dollars) where the PC was in mid-70s
  - So is the relative maturity!
- Prices will drop, capabilities will improve
  - 3D printers in every home in 20 years?



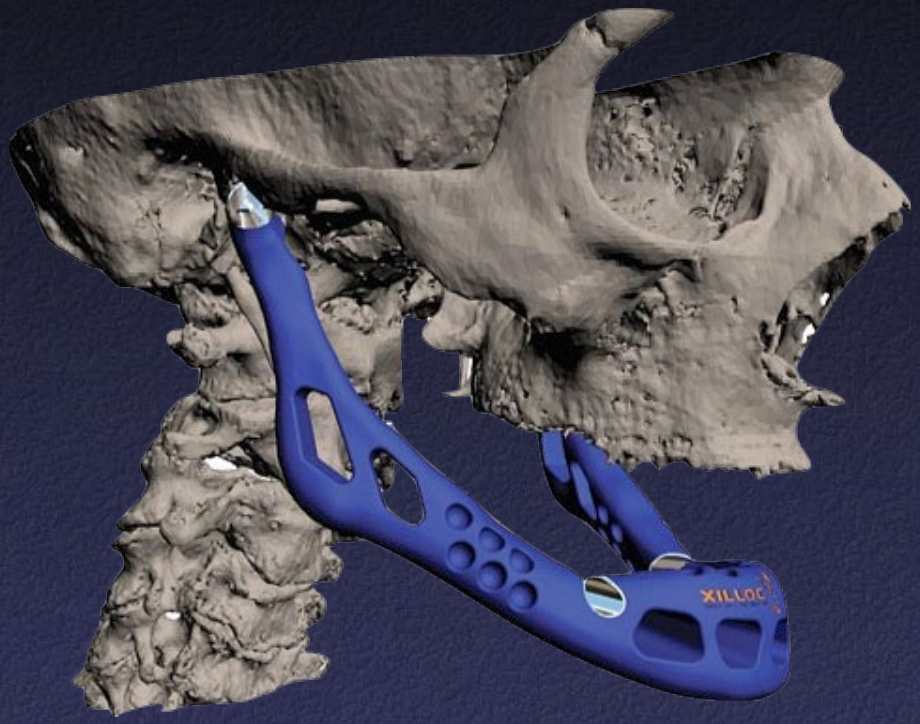
The Design Economy

- When people can turn a computer file into a useful solid object, those computer files will become products
- People with CAD skills, or 3D scanners, will make them
- People with printers will buy them
- Another opportunity for the developing world?

New Business Models

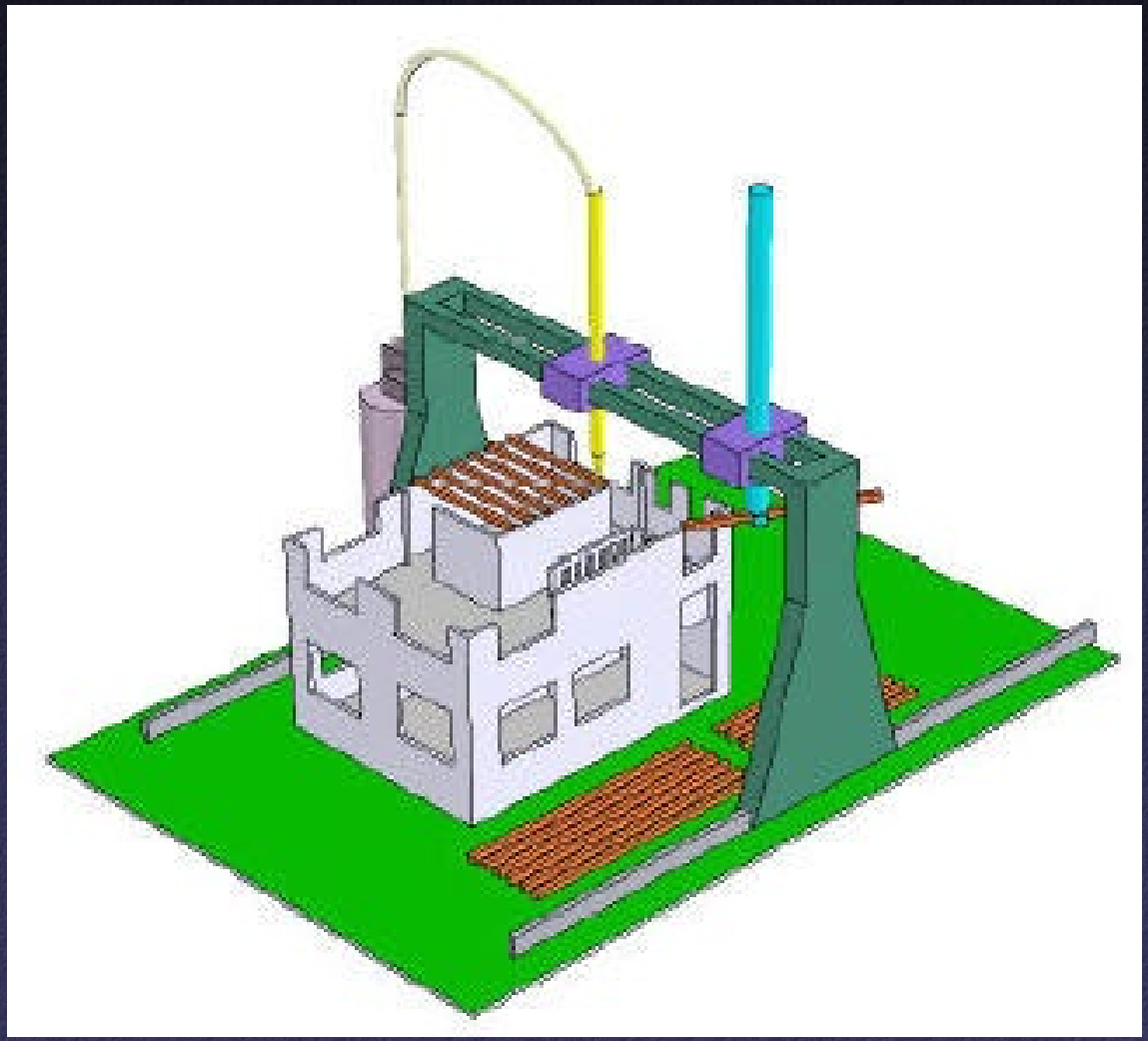
- Sell (and customize) 3D models, not widgets
- Sell raw materials
- Sell equipment to recycle materials
- Sell a printer linked to file source (Think Kindle!)

Emerging Applications: Bioprinting



Emerging Applications: Food

Emerging Applications: Architecture



Towards Computational Fabrication

- Going beyond simple slicing to enable design for desired appearance, deformation, structural properties, etc.
- As with computational photography:
  the ability to perform complex computation allows for a greater range of capabilities

Computational Fabrication Pipeline