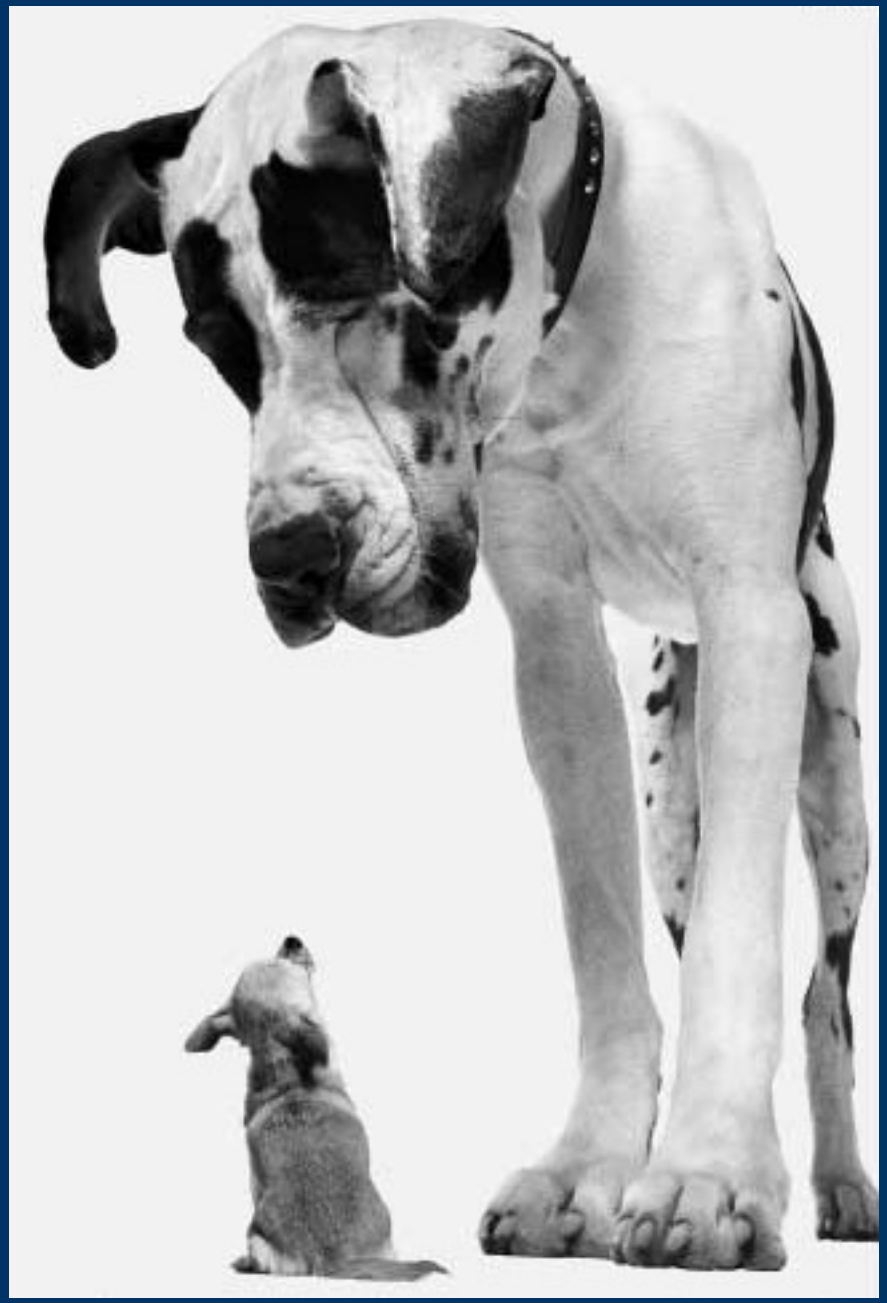
RepRap - self-replicating production

Adrian Bowyer
Bath University, UK

How To Make Something That Makes (almost) Anything
MIT CBA 17-2-2009

Breeding



RepRap

Advanced genetic engineering equipment

RepRap

Symbiosis

nectar <> reproduction

RepRap

Symbiosis

nectar <> reproduction

RepRap

Symbiosis

nectar <> reproduction

cake <> reproduction

RepRap

Suppose we made a machine that:

- Self-replicated almost all its parts

- Existed symbiotically with people, giving them goods in return for being helped to replicate (like flowers)...

- RepRap - The **Rep**licating **Rap**id Prototyper Project

RepRap

Rapid Prototyping

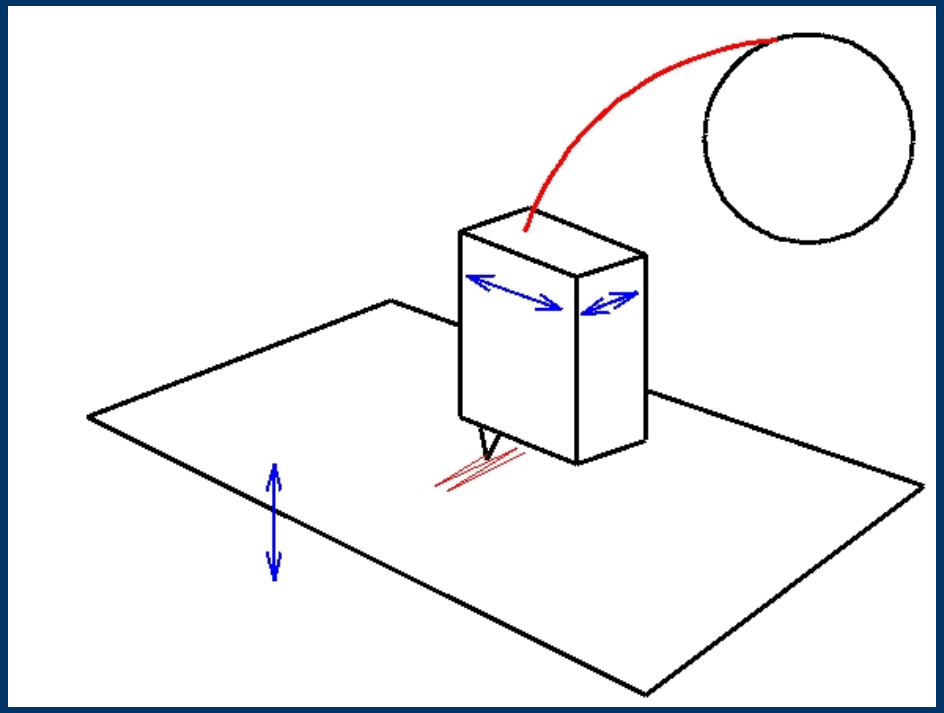
David Jones - "Daedalus" - (*New Scientist*, 3 October 1974)

Wyn Kelly Swainson patent published in 1977.

Now many different technologies.

RepRap

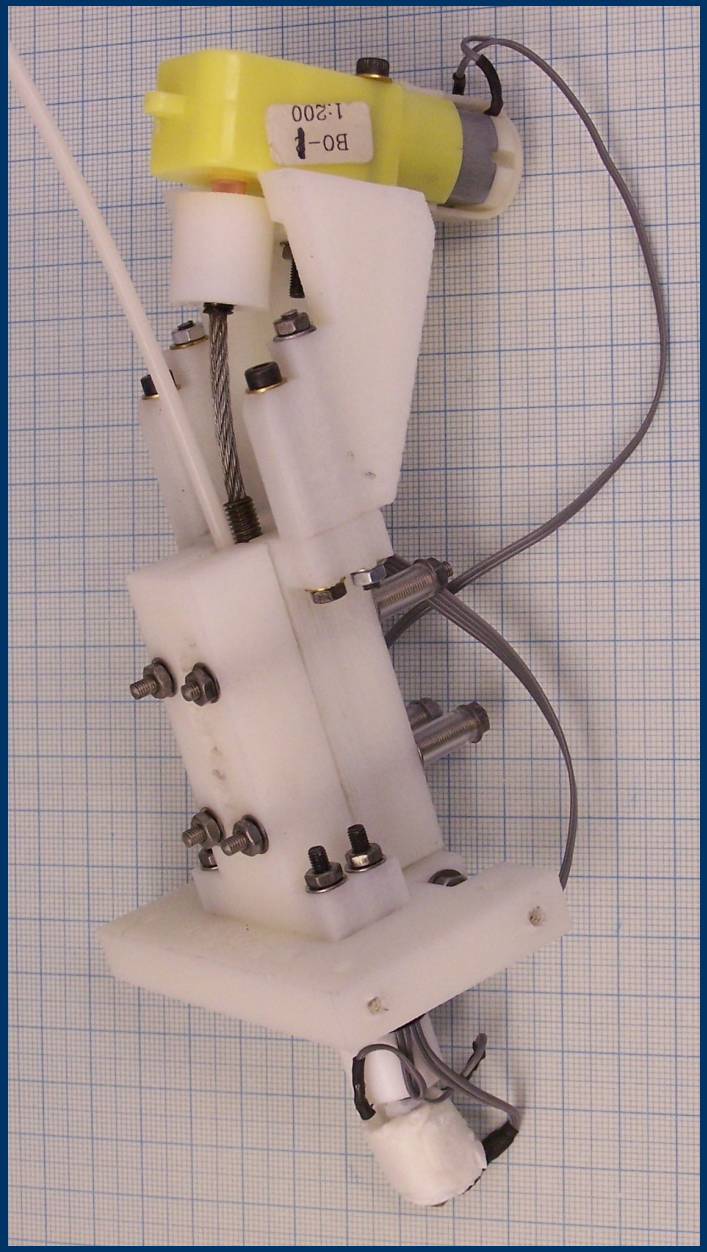
FDM rapid prototyping

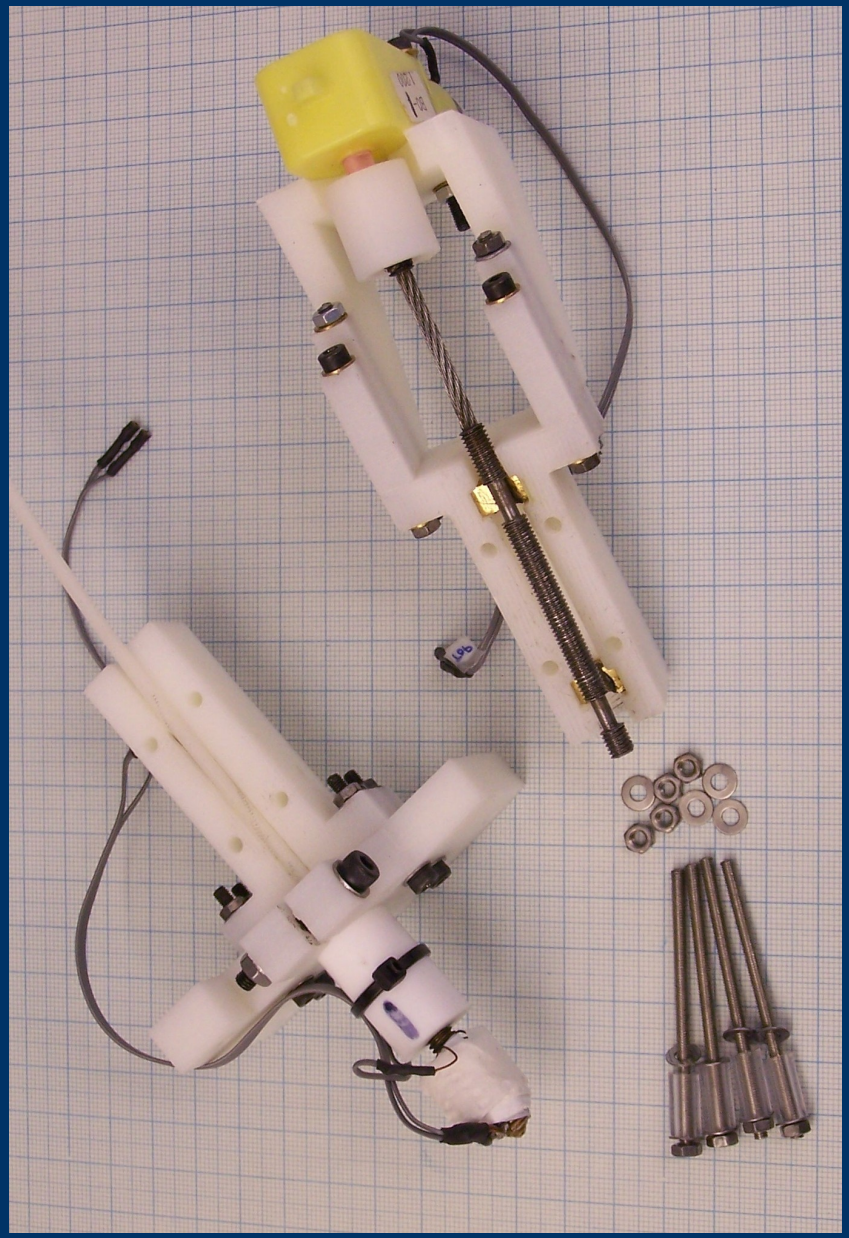


Fused Deposition Modelling

RepRap

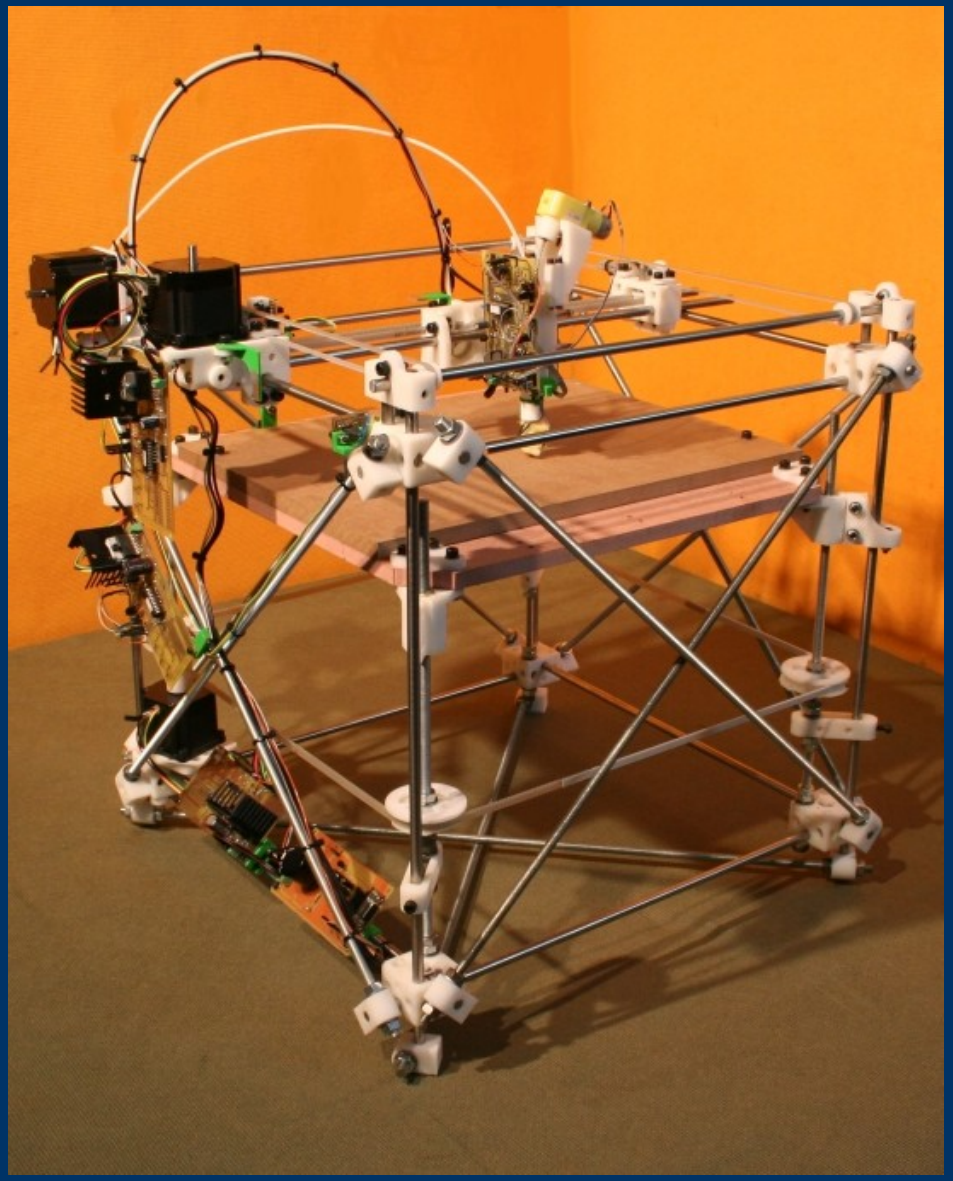
Rapid-prototyped write-head





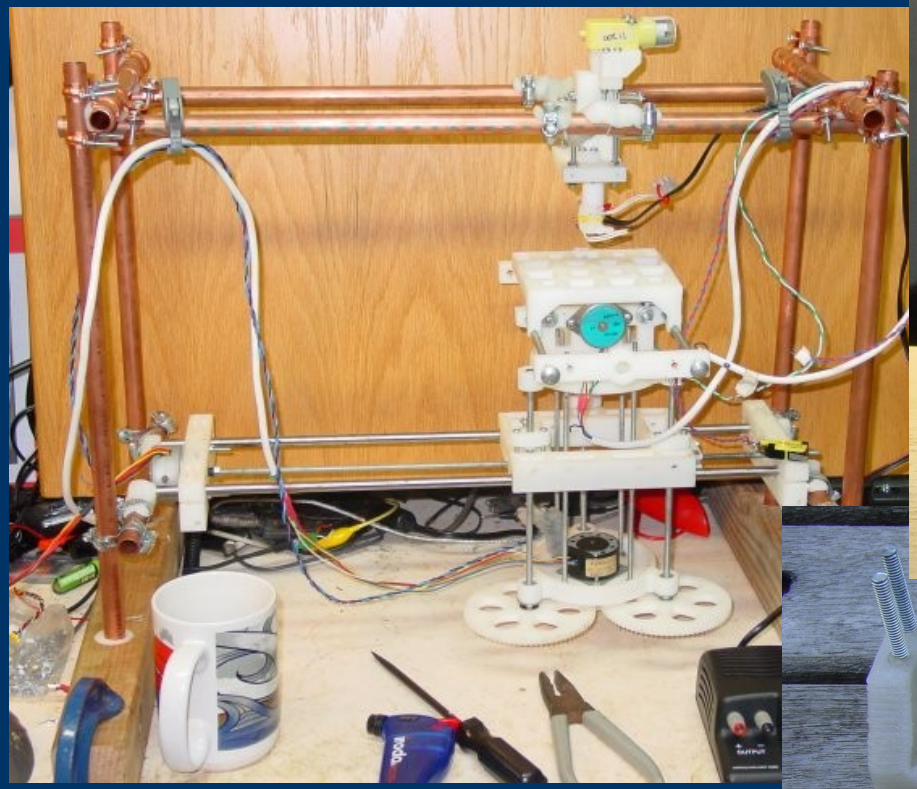
RepRap

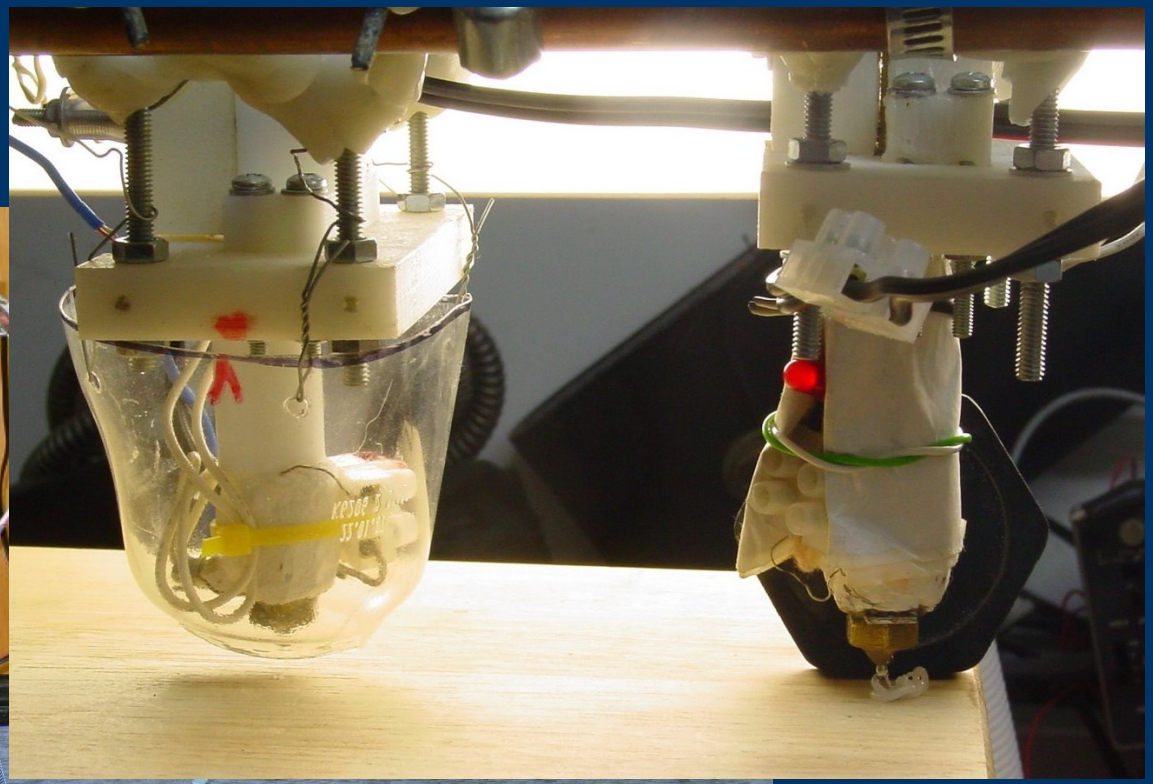
Rapid-prototyped X, Y, Z robot

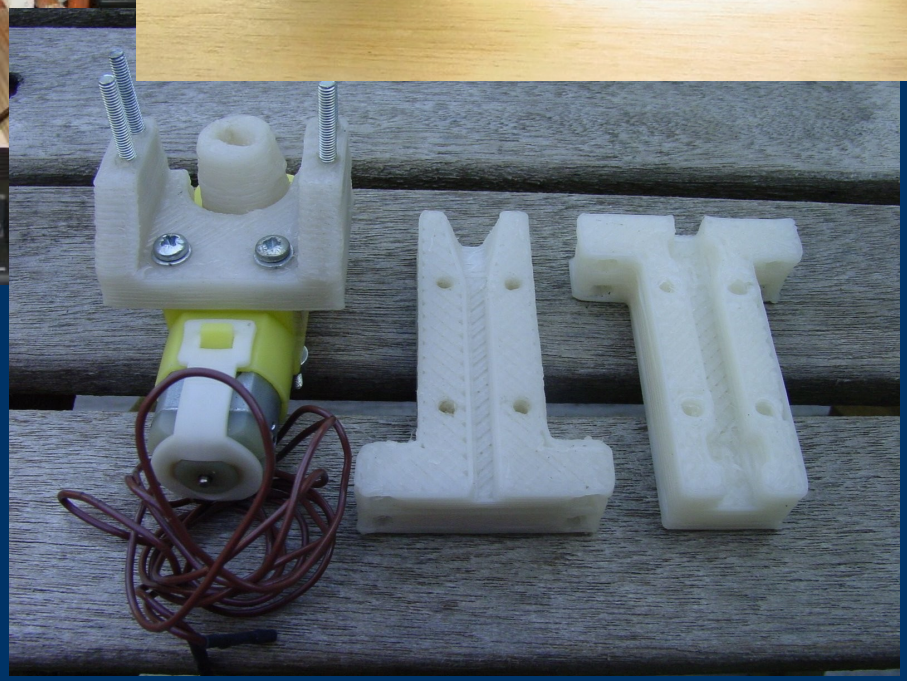


RepRap

Does it work?



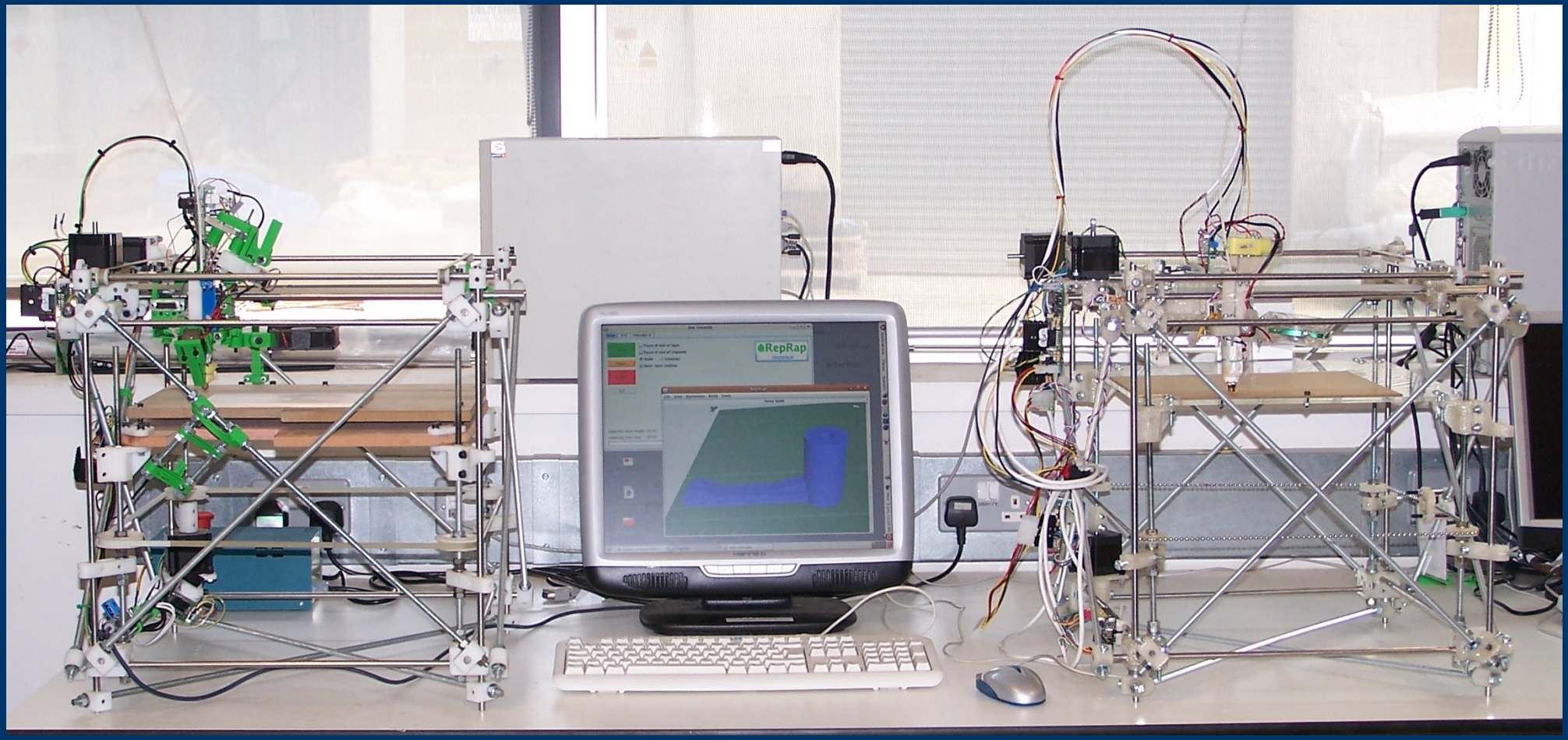




Testbed machine

RepRap

Does it work?

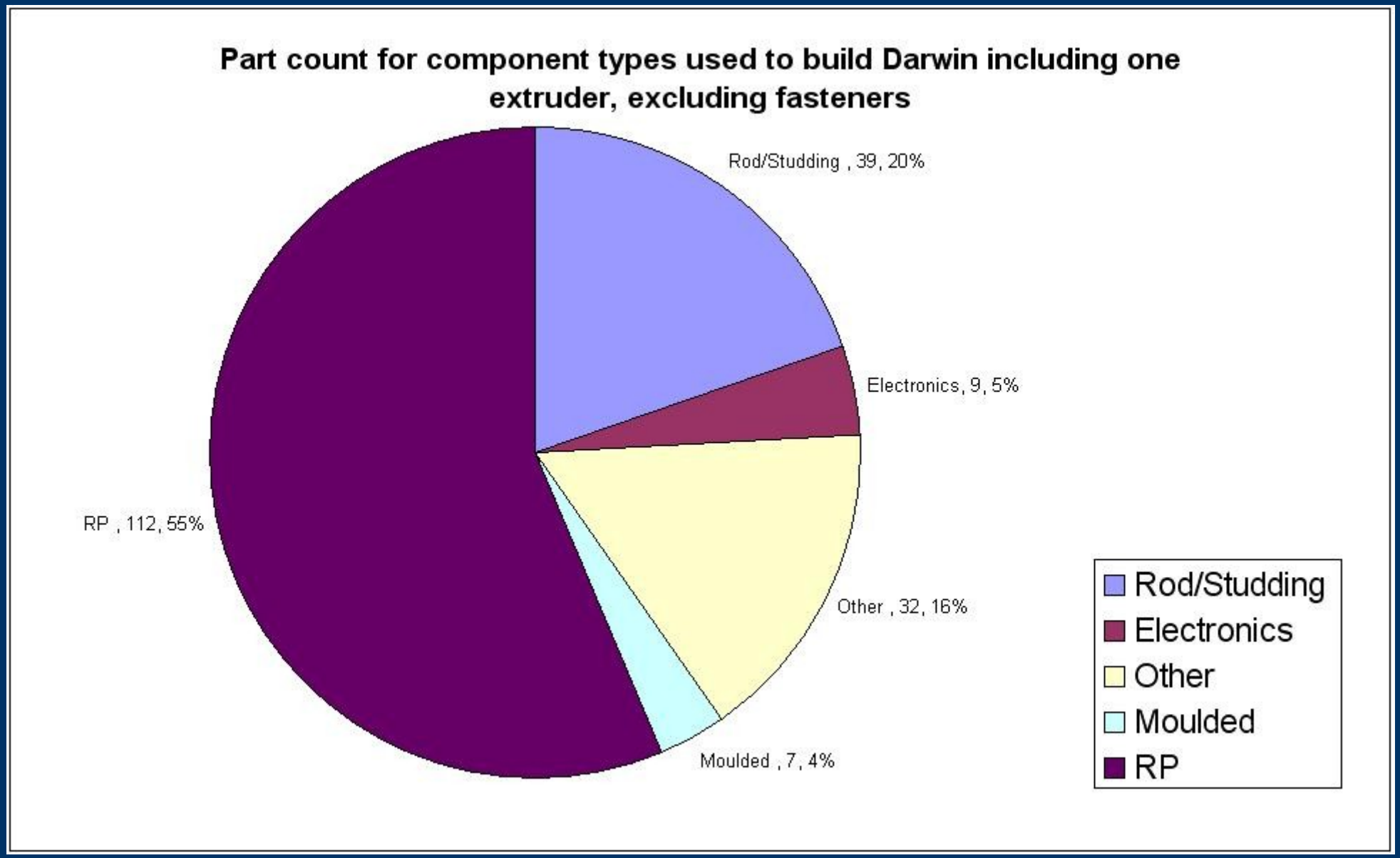


Parent

Child

RepRap

RepRap part count



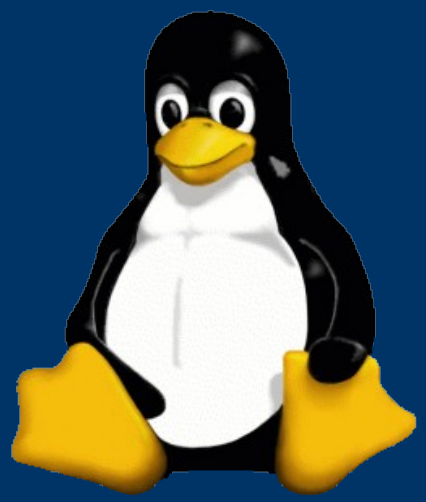
RepRap

Hubris

What will happen if RepRap takes off?

RepRap

Start by making RepRap open-source



Linux

RepRap

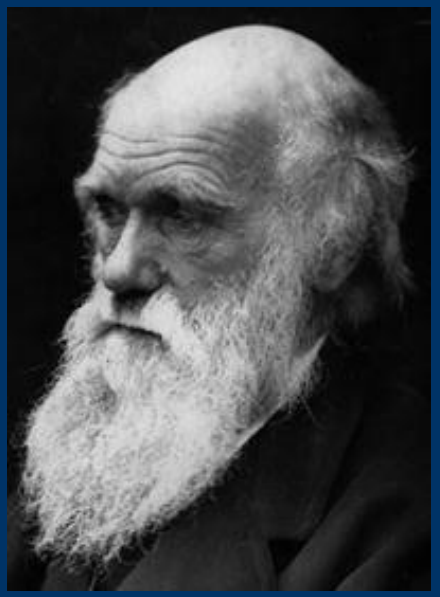
Exponential growth

10,000 per hour

Say the RepRap machine takes one day to copy itself, and to make one comb...

RepRap

Evolution



The design files (genotype) have to be available with the RepRap machine (phenotype) for it to be able to copy itself.

- People will improve the design.
- Some improvements will be posted back on the Web.
- Old machines can make new designs.
- Artificial selection – speed, simplicity, accuracy, fewer added parts...

RepRap

Economics

It doesn't matter how much the first RepRap machine costs, all the rest will cost:

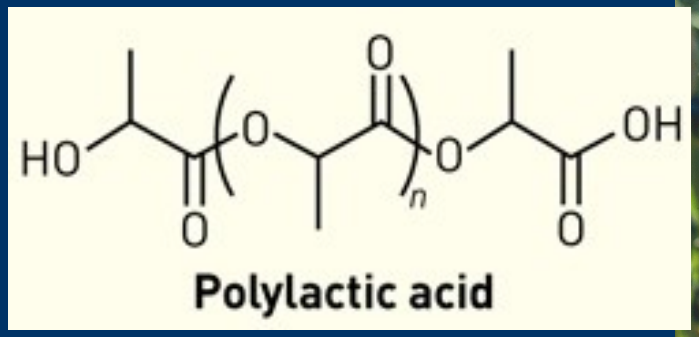
raw-materials + assembly-time.

- Once you have one, you can have any number.
- No one can make money by selling RepRap.
- Target cost of raw materials, motors, chips etc:

$450

RepRap

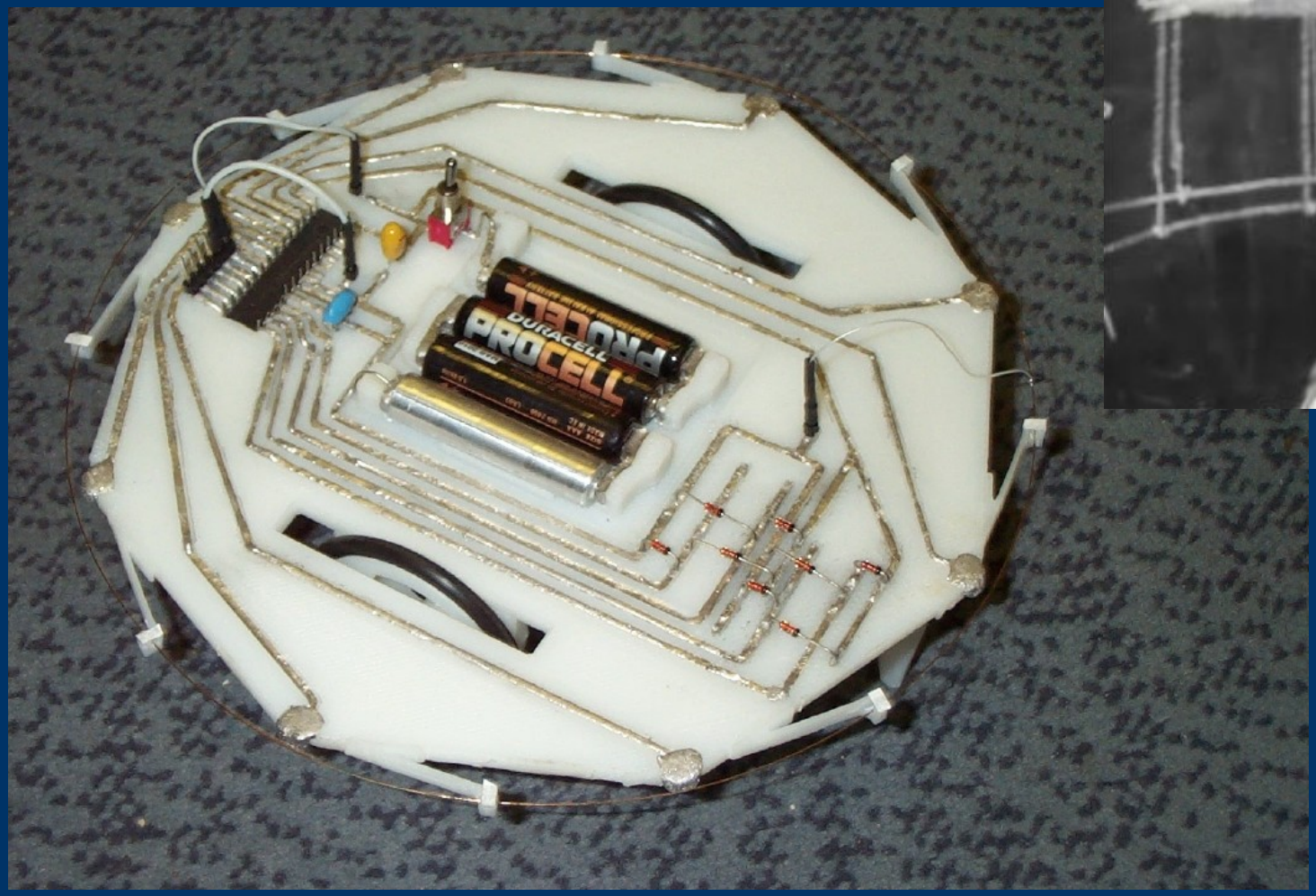
Environment

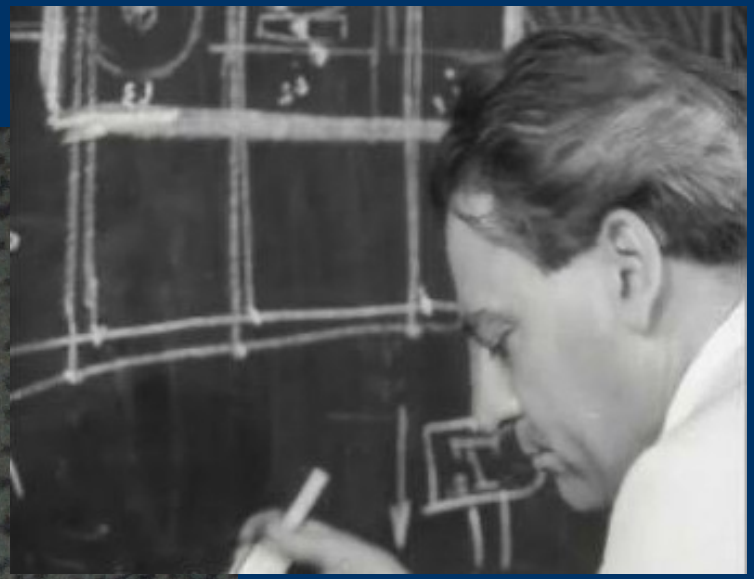


- Material supply - biomass.
- Bringing manufacturing to the poorest people.
- Making manufacturing like agriculture.
- Recycling.

RepRap

Rapid-prototyped electric circuits





John Sargrove

RepRap

The Future?

Almost everyone in the developed world runs their own:

- **CD pressing plant**

RepRap

The Future?

Almost everyone in the developed world runs their own:

- **CD pressing plant**

- **Photographic laboratory**

RepRap

The Future?

Almost everyone in the developed world runs their own:

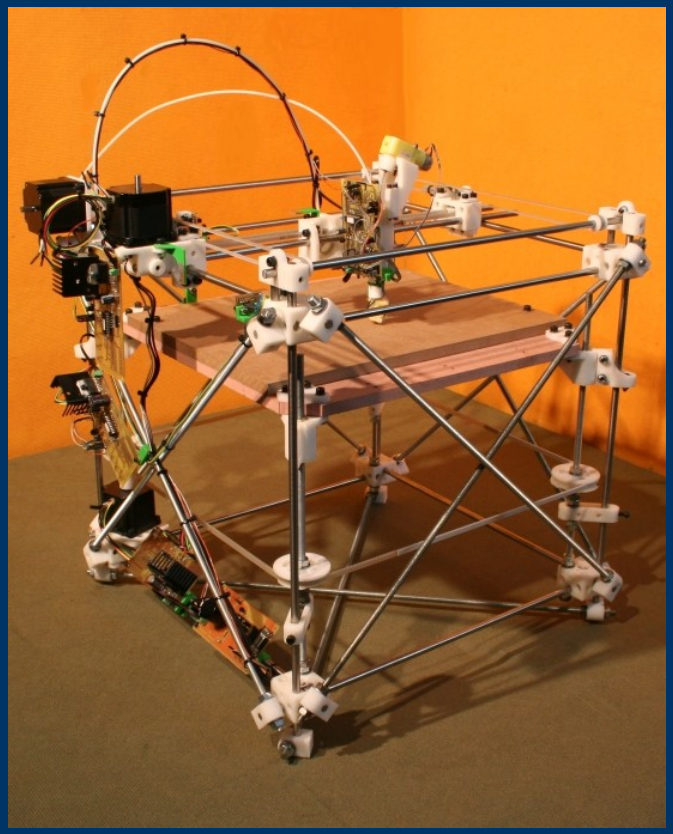
- **CD pressing plant**

- **Photographic laboratory**

- **Printing press**

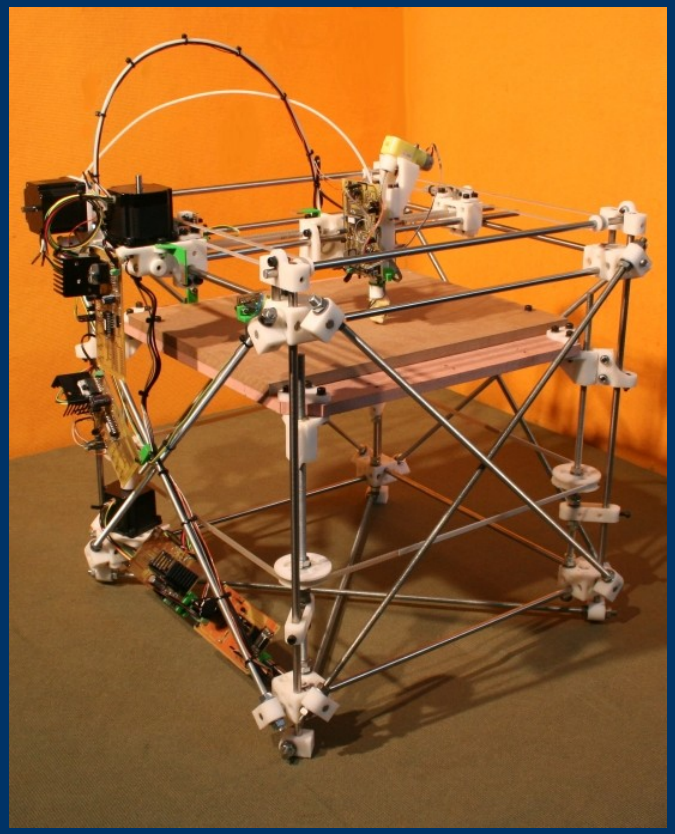
RepRap

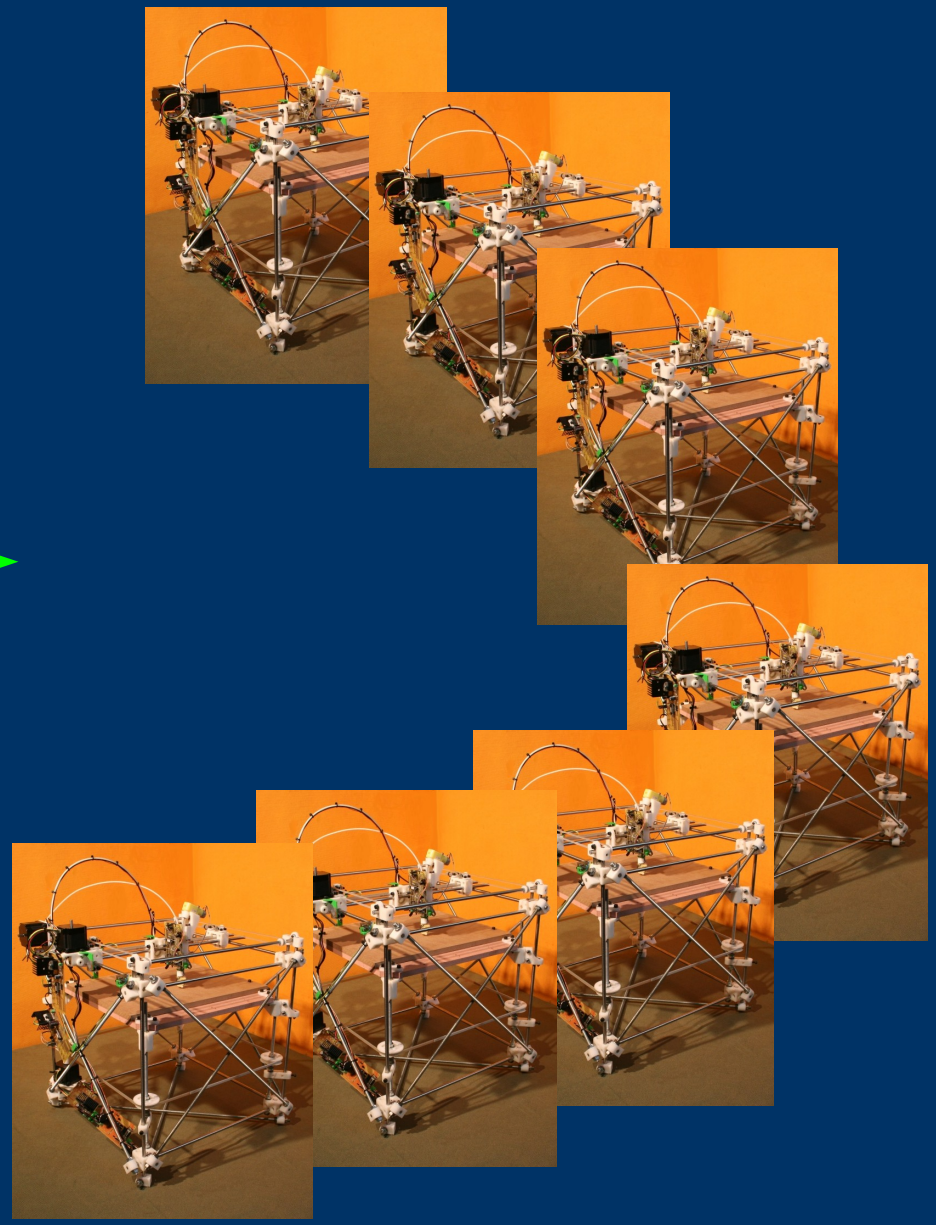
Why not their own factory...



RepRap

...that makes more factories?





RepRap

"Money is a sign of poverty."

- Iain M. Banks, 1987.

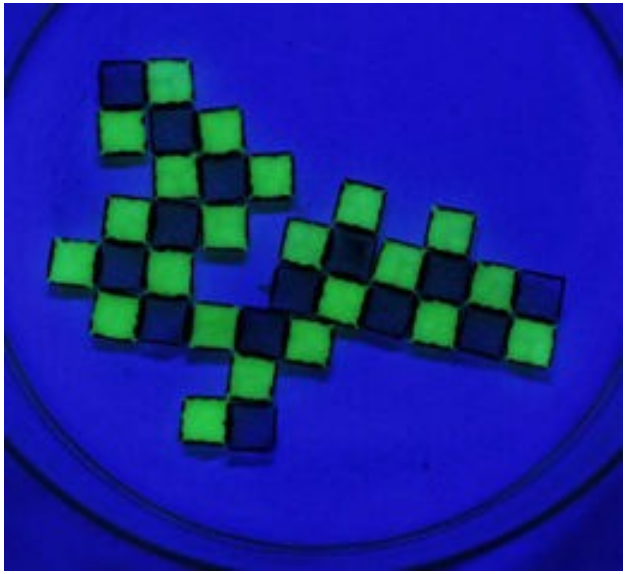
Project website:

http://reprap.org

RepRap

Adrian's attempt at the assignment...

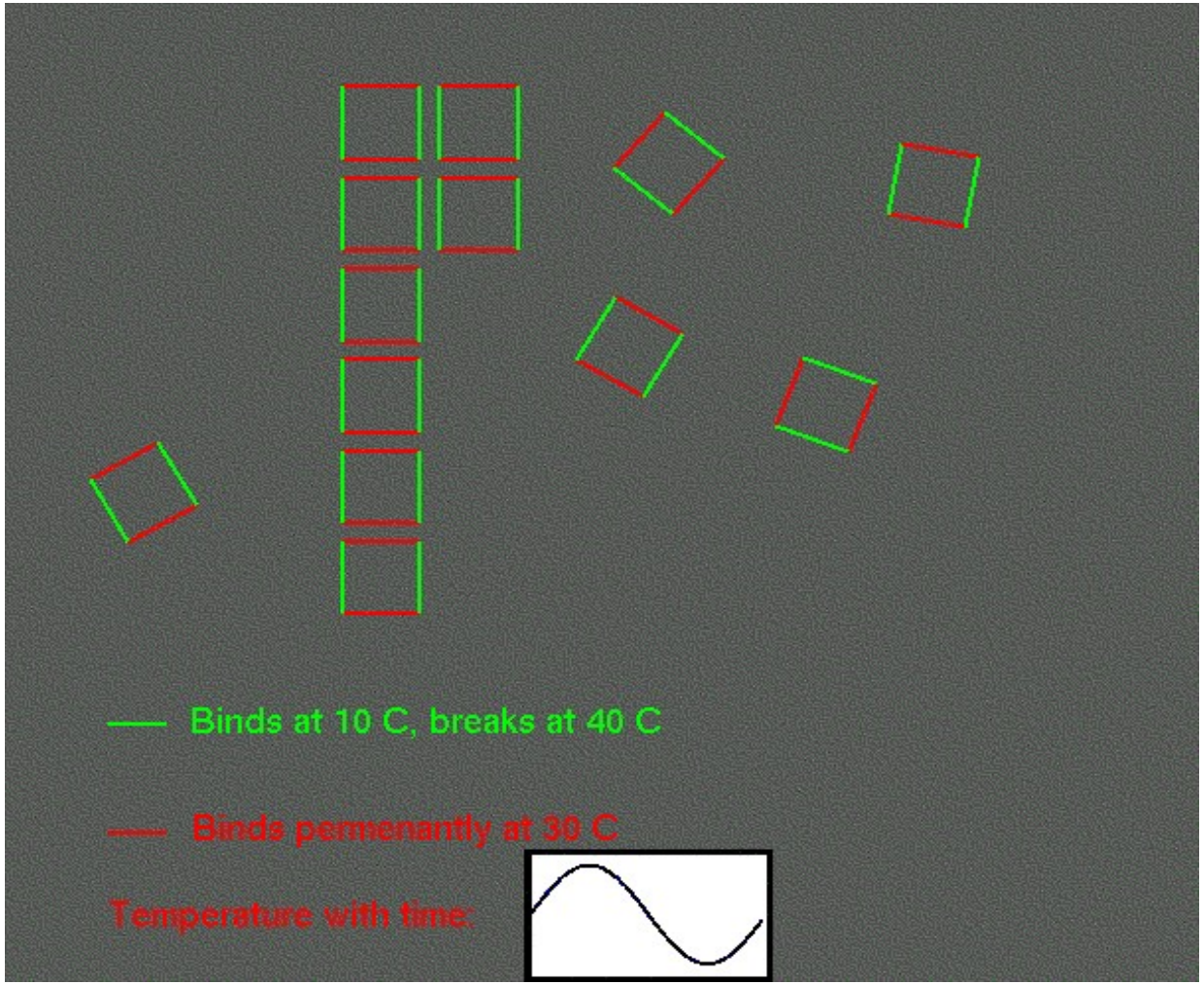
Smart bricks



2-D experiments floating on water. Forces: hydrophobic, hydrophilic. Tile size: 1 – 5 mm.

Whitesides, G., *et al*., "Crystallization of Millimeter-Scale Objects with Use of Capillary Forces", *J. Am. Chem. Soc.*, **1998**, 120, 12670-12671

Self-assembling replicators; stir, warm, and cool...



Poly-(N-IsoPropyl-AcrylAmide) is hydrophobic above 37 C and hydrophilic below 32 C.

Melamine resins with a high concentration of secondary amino groups can cure at low temperature in acidic conditions.

Singh, D. *et al.*: Studies on copolymerization of N-isopropylacrylamide with poly(ethylene glycol) methacrylate, *European Polymer Journal*, V. 44, #9, September 2008, Pages 2962-2970.
Holmberg, K.: Low temperature acid catalyzed curing of melamine resin systems, *Polymer Bulletin,* V.11, #1, Springer ISSN 0170-0839 (1984).