

# Approaches to Making Open Source the Default in Academia

Joshua M. Pearce

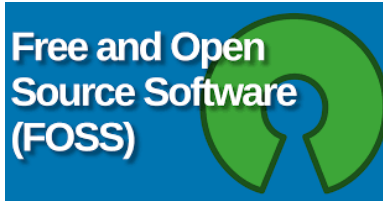
John M. Thompson Chair in Information Technology and Innovation  
Director of the Free Appropriate Sustainable Technology (FAST) Lab  
Department of Electrical & Computer Engineering  
Ivey Business School  
Western University, Canada



# Our Team is



- FOSS

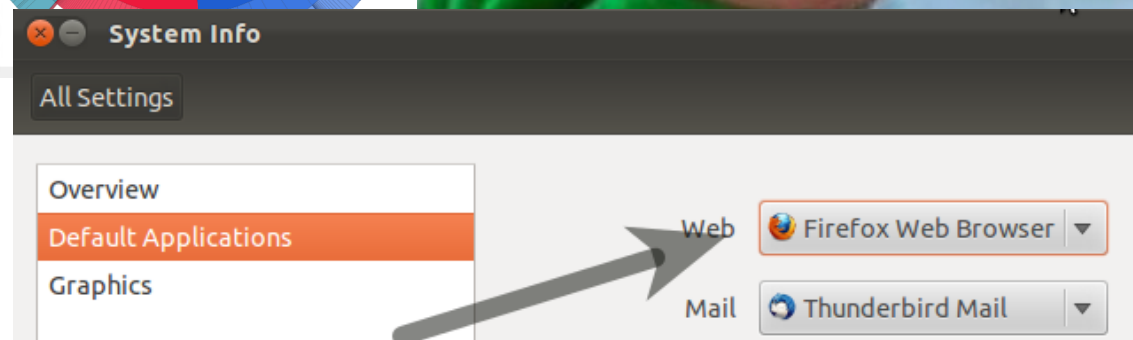
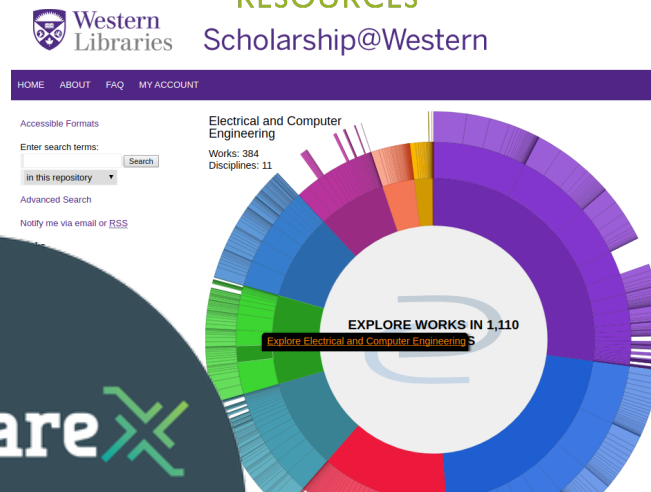


- Open Educational Resources



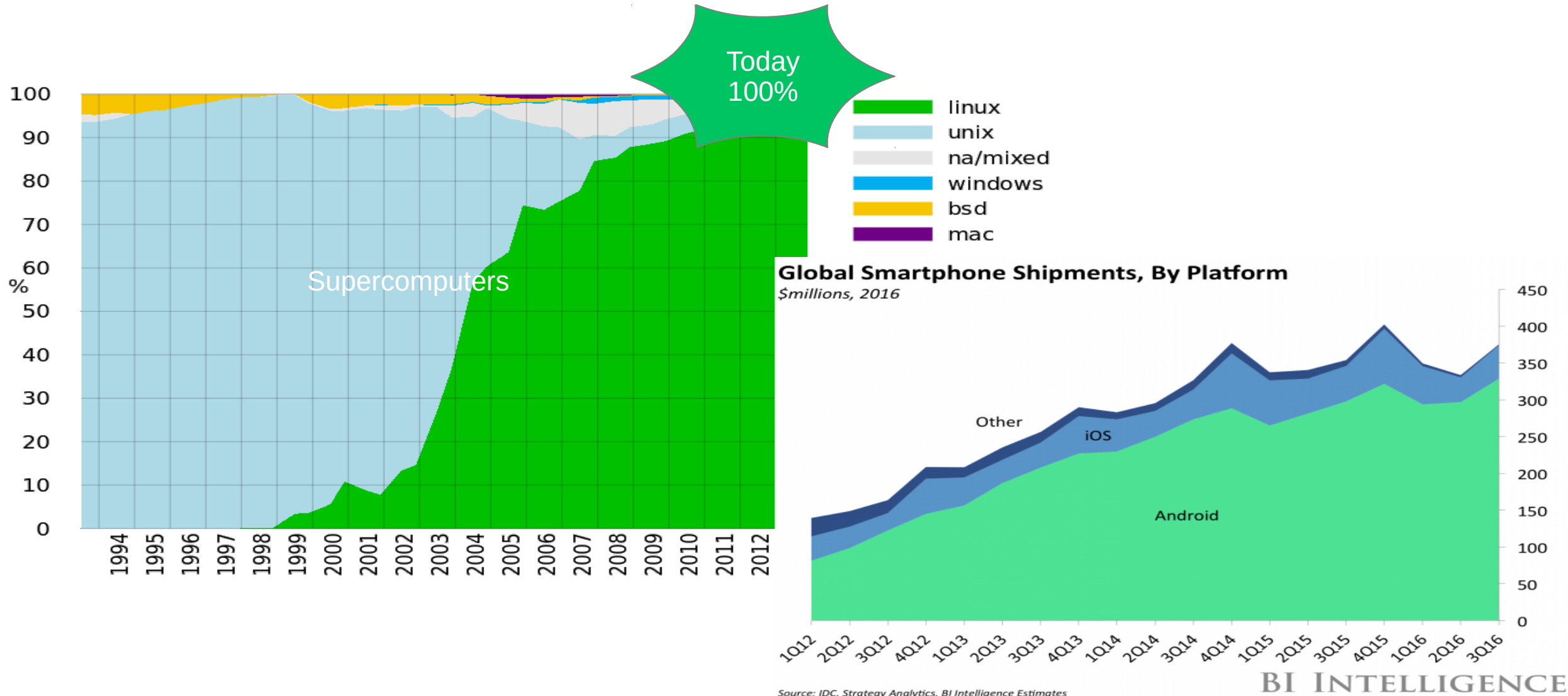
- Open Access

- FOSH



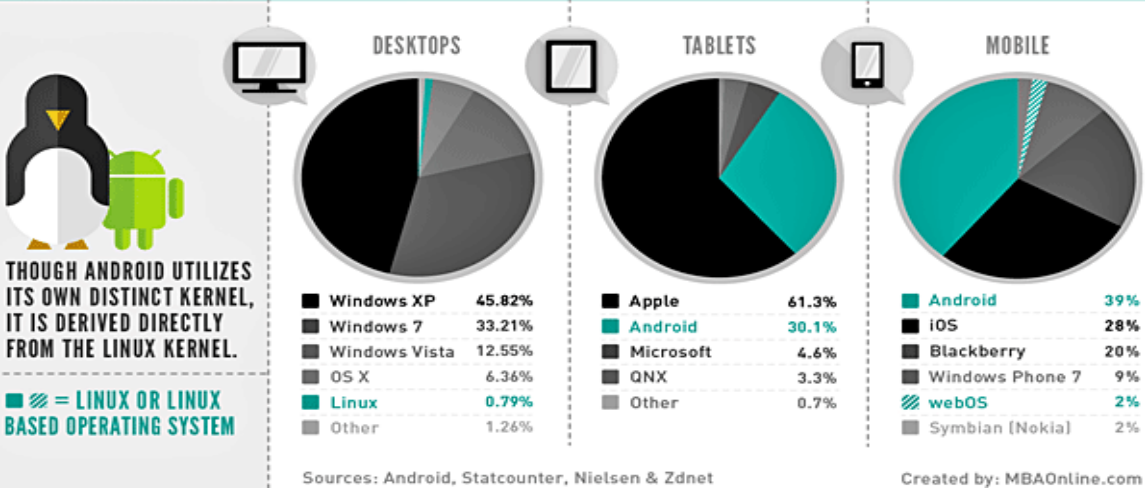


# Supercomputers or Smartphone



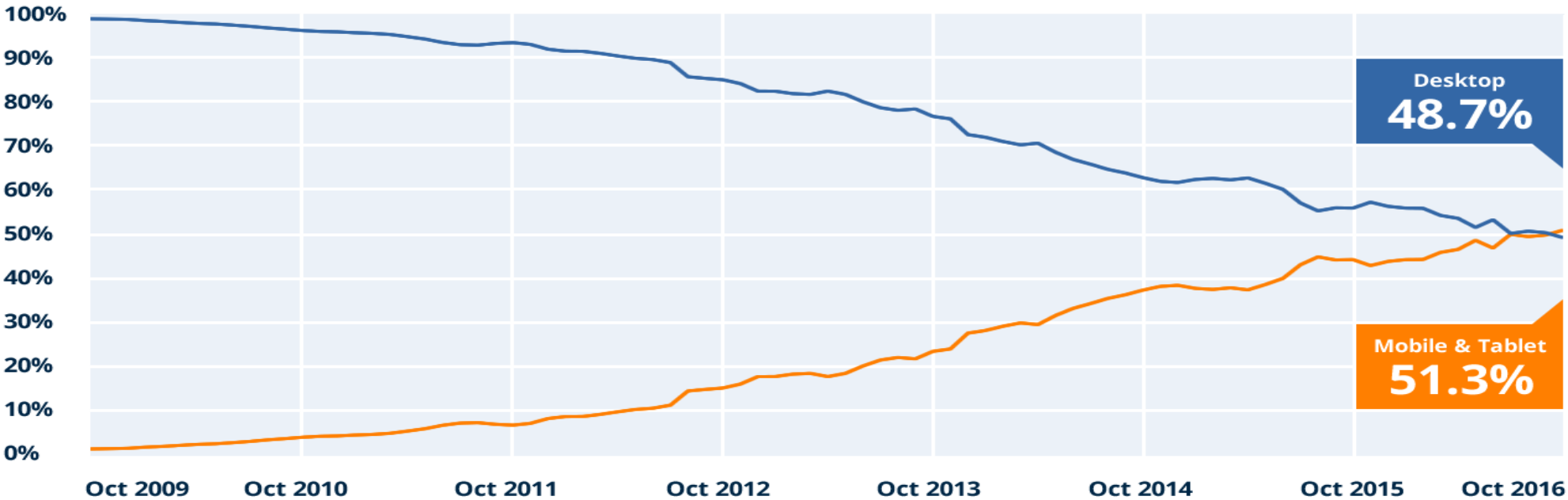
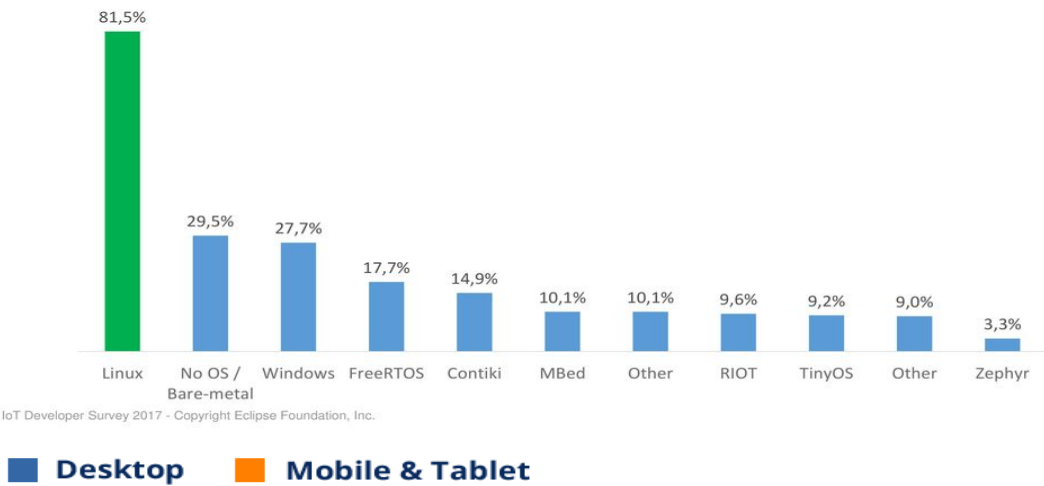
# OS Has Taken Over the Future

## LINUX MARKET SHARES



## IoT OPERATING SYSTEMS

Which operating system(s) do you use for your IoT devices? (Summary)







We believe that applying the open source philosophy to our patents will strengthen rather than diminish Tesla's position...  
- Elon Musk

Elon Musk / Net worth

214.8 billion USD

2021



People also search for



Jeff Bezos  
197.8B USD



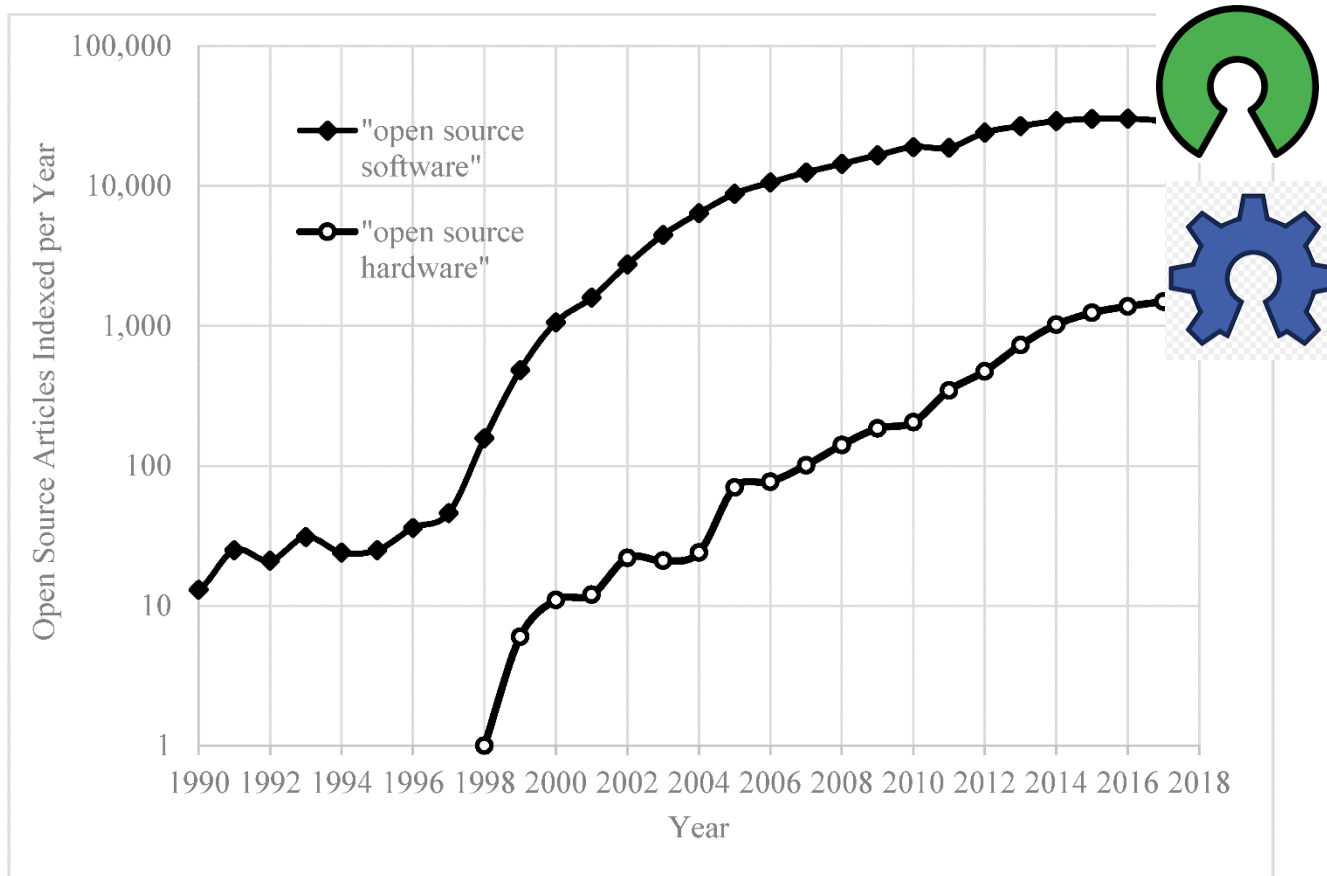
Bernard  
Arnault  
185.6B USD



Bill Gates  
132.7B USD



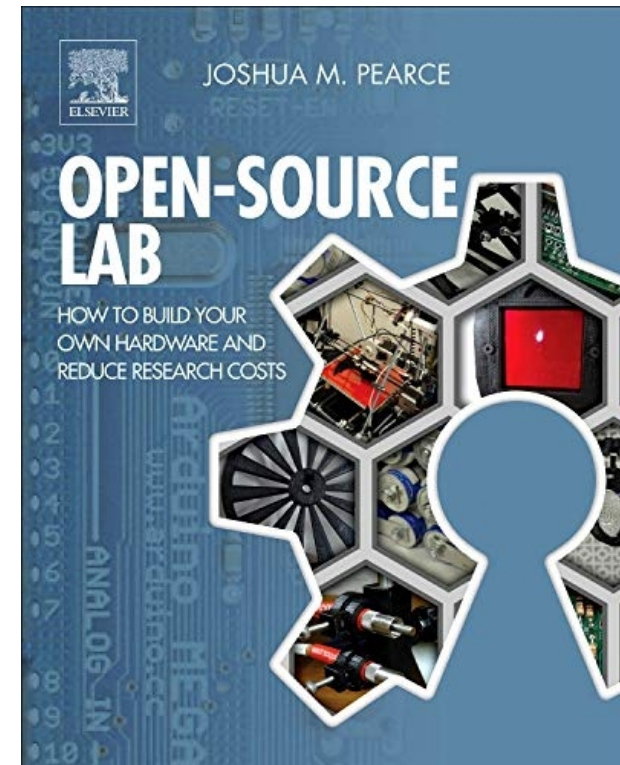
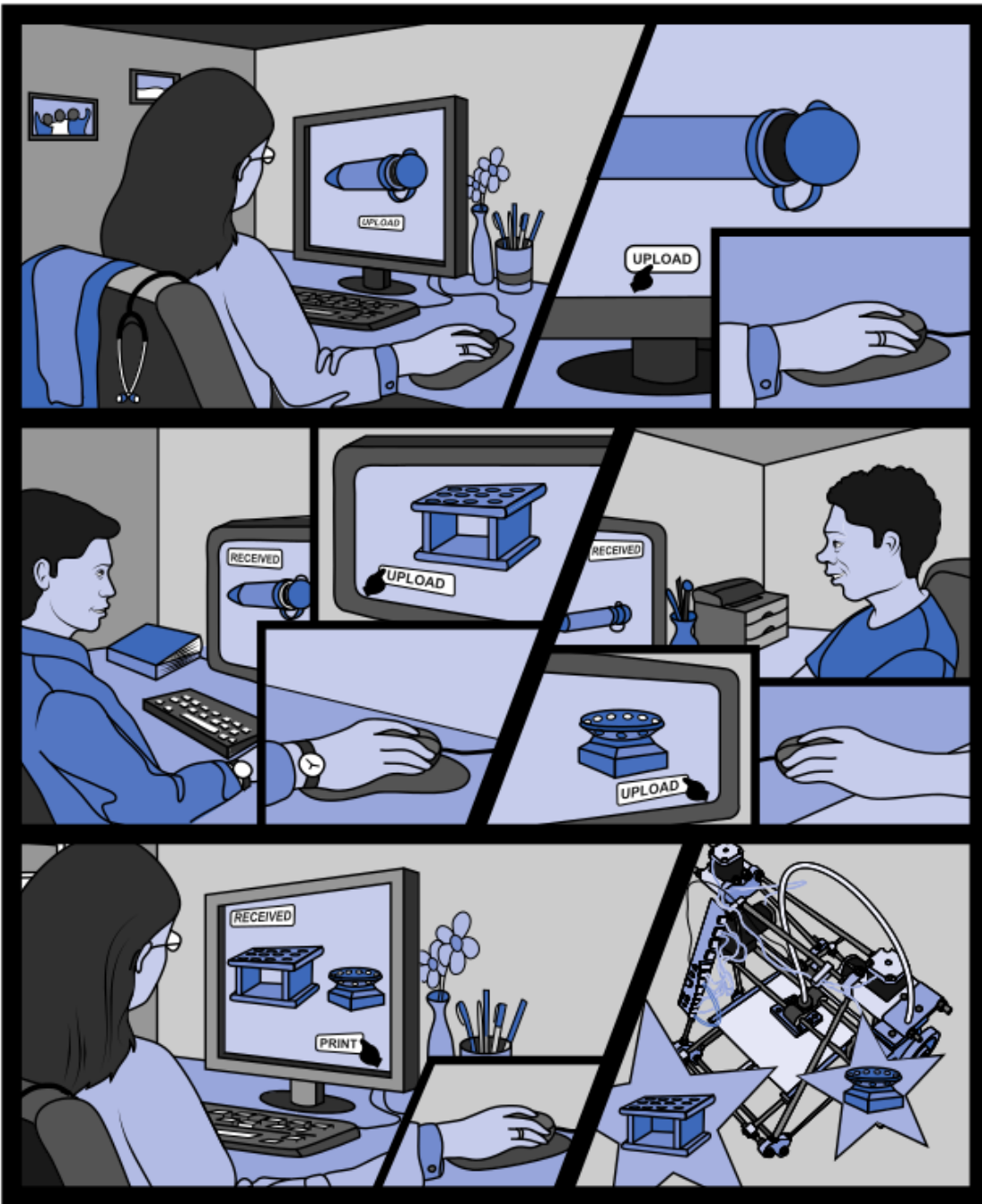
# Free and Open Source Hardware (FOSH) not far behind FOSS



Pearce, J., 2018. Sponsored Libre Research Agreements to Create Free and Open Source Software and Hardware. *Inventions*, 3(3), p.44.

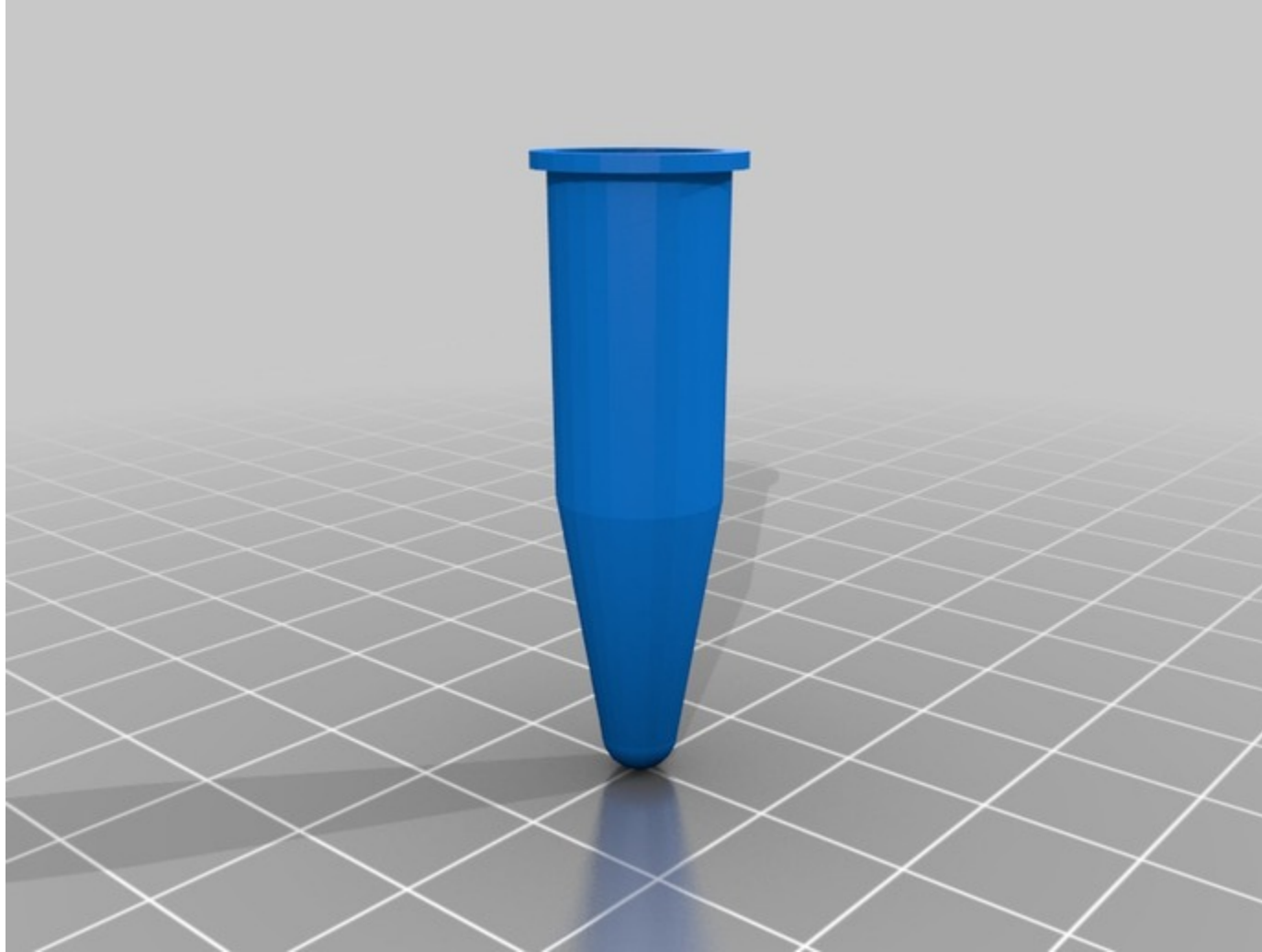


# How OS Works With Distributed Manufacturing Now in Academic Labs

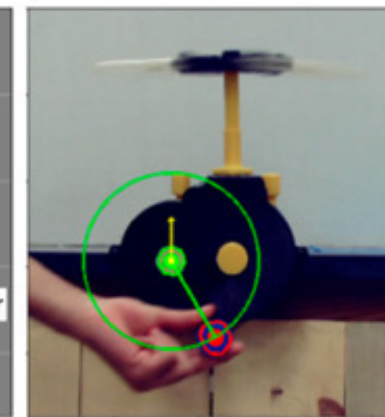
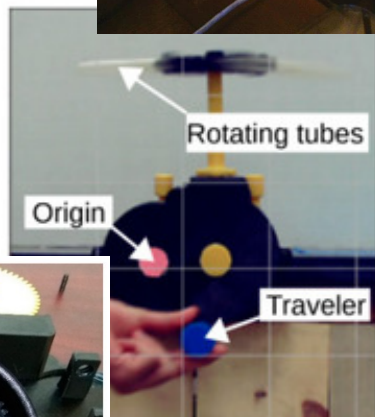
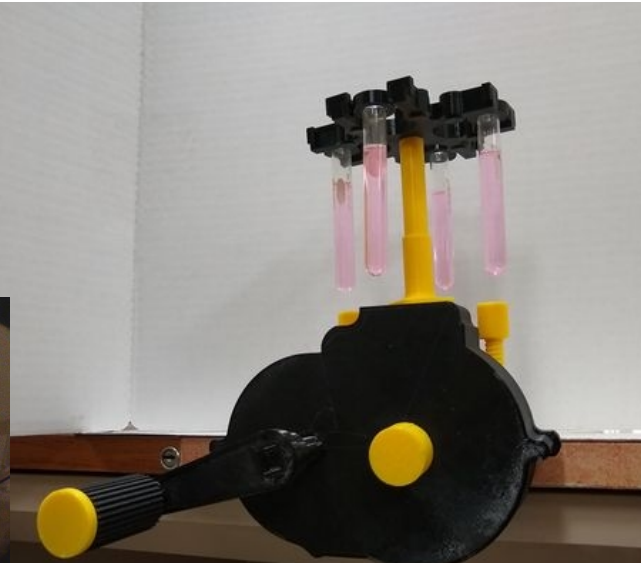
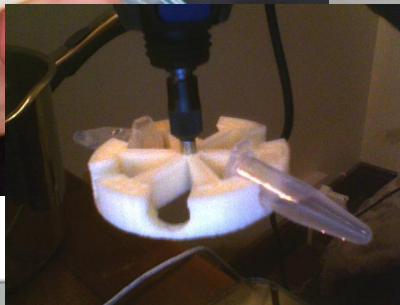
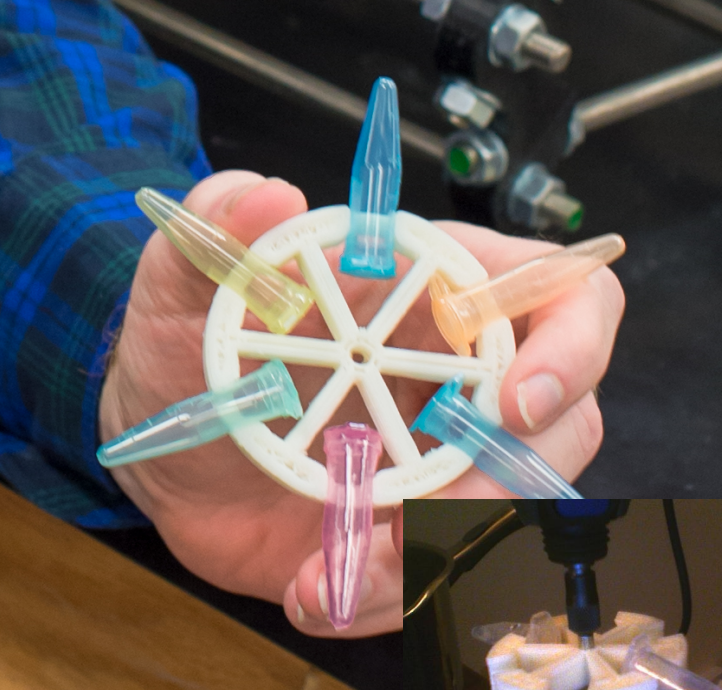




# Simple Designs → Complexity



# Centrifuges



(a)

(b)

(c)

Salil S. Sule, Aliaksei L. Petsiuk and Joshua M. Pearce.  
Open Source Completely 3-D Printable Centrifuge.

*Instruments* 2019, 3(2), 30;

<https://doi.org/10.3390/instruments3020030>

## BIOMEDICAL CENTRIFUGE

Set centrifuge parameters

Set Gear Ratio 10

Set Tube Length 15

Open CAM

Open Video

Open the region of interest

0

0

600

800

SET VALUES AND CROP

Set RGB thresholds

R

G

B

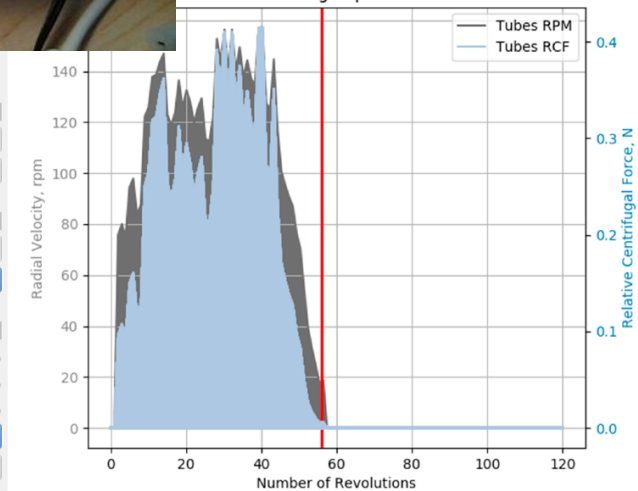
Trace Markers

PLOT RCF(RPM) FUNCTION

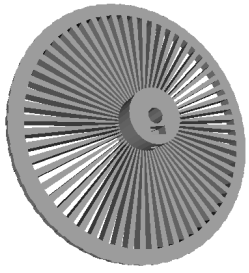
Reset Timer

627.22 s

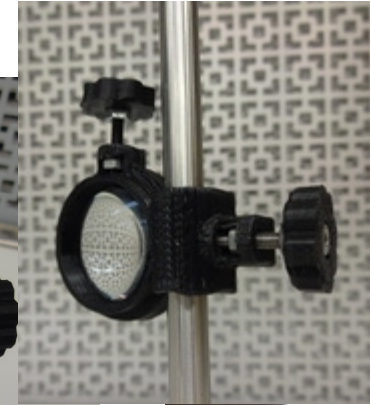
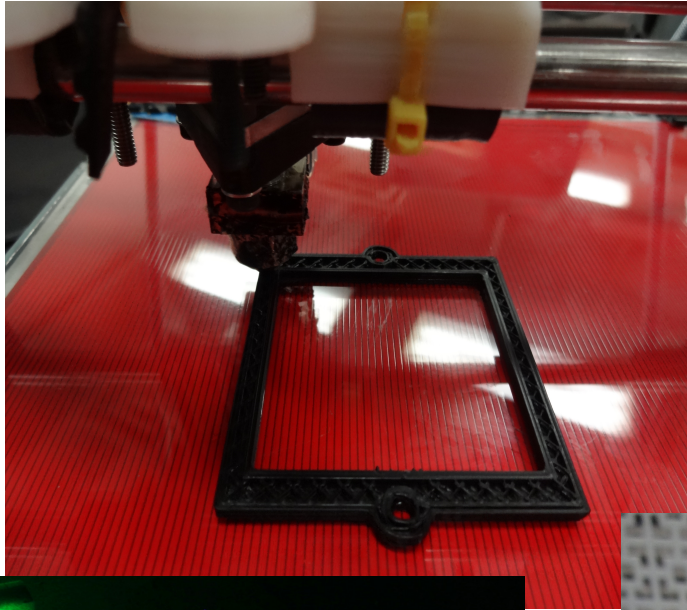
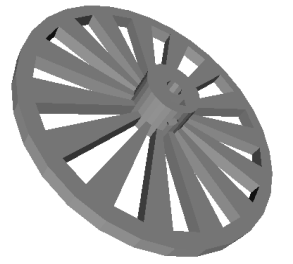
## Centrifuge Spin Test



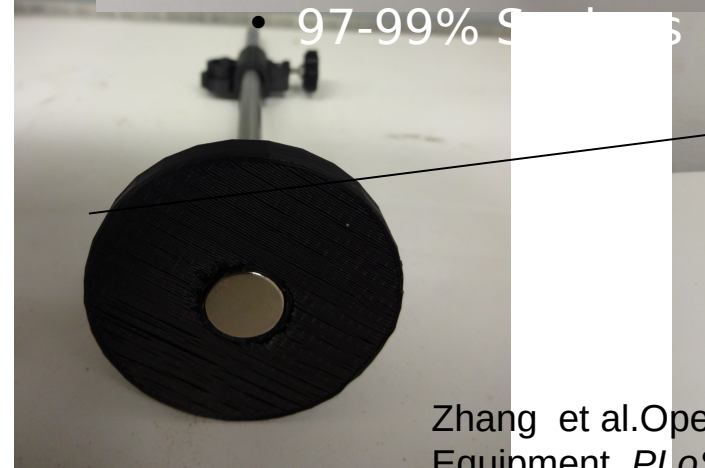




# Open Source Optics Library



Optical rail sells for \$380/m.  
Open beam only costs \$12/m



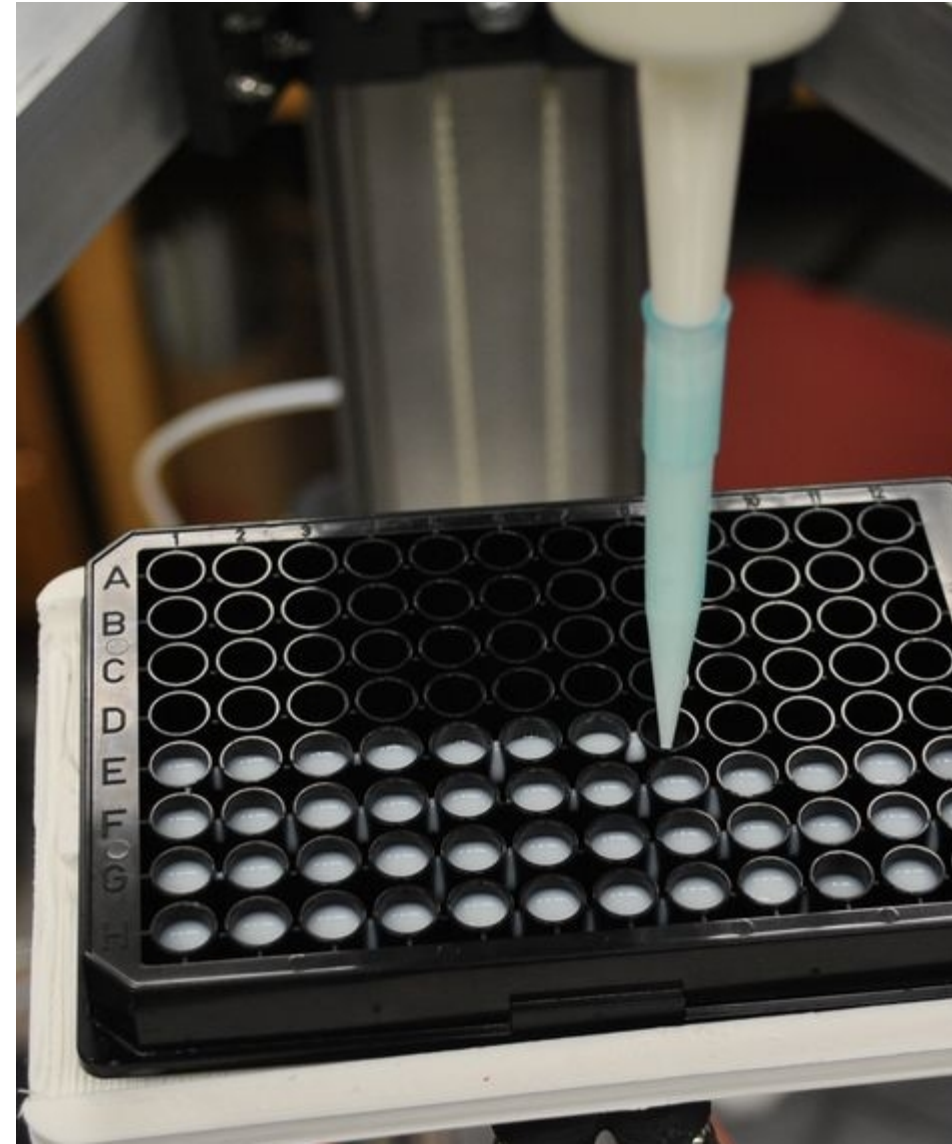
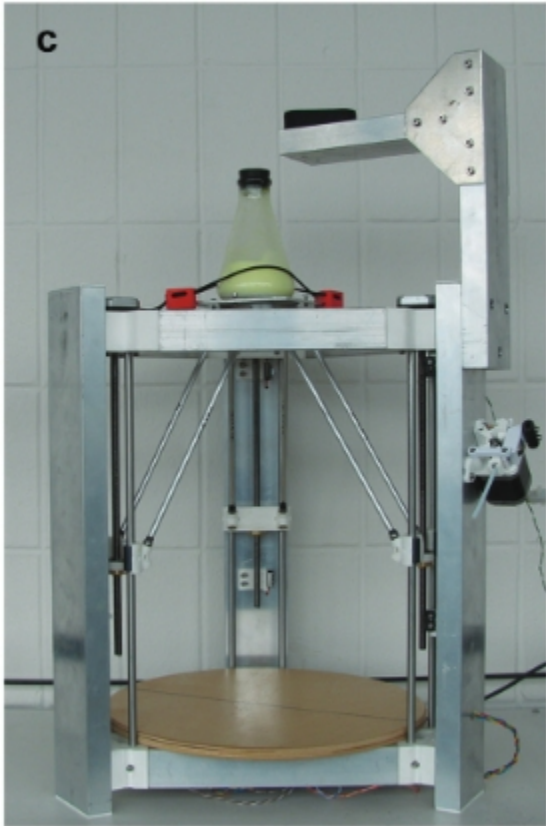
• 97-99% S...



Zhang et al. Open-Source 3D-Printable Optics  
Equipment. *PLoS ONE* 8(3): e59840



# 3-D Printer Becomes Highly Flexible Sci-Tool for Automation



Chenlong Zhang, Bas Wijnen, Joshua M. Pearce. Open-source 3-D Platform for Low-cost Scientific Instrument Ecosystem. *Journal of Laboratory Automation*, 21(4), 517-525.



# Nations Have Opportunity to Get Far More When Funding Research at Universities

- Distributed digital manufacturing of open source hardware results in 90-99% savings compared to conventional processes
- Fulbright-Aalto University Distinguished Chair
- Finland's science funders could save between 2.84–27.7m€/year directly on scientific equipment purchases if research hardware is converted to FOSH
- Combining both Arduino and 3-D printing the savings averaged 94% for free and open source tools over commercial equivalents.

Pearce, J.M. *Science*, 337(6100), pp.1303-1304 (2012).

Pearce, J.M., 2013. *Open-source lab: how to build your own hardware and reduce research costs*. Elsevier.



I.T.S.Heikkinen H.Savin, J.Partanen, J.Seppälä, J.M.Pearce. Towards national policy for open source hardware research: The case of Finland. *Technological Forecasting and Social Change* 155, (2020), 119986. <https://doi.org/10.1016/j.techfore.2020.119986>

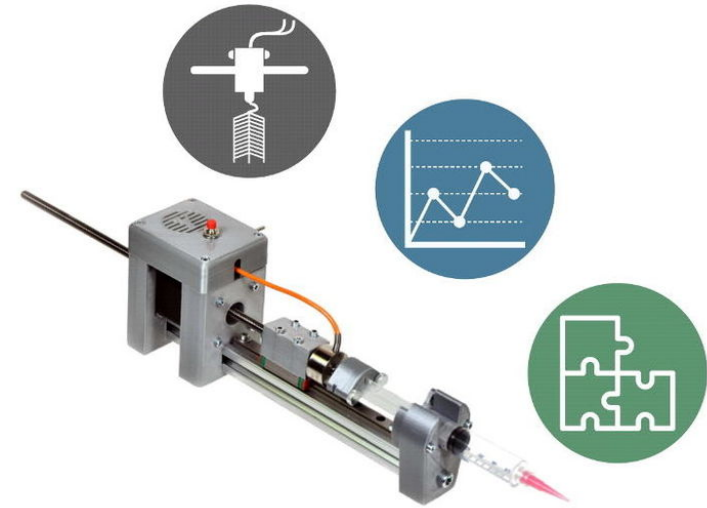
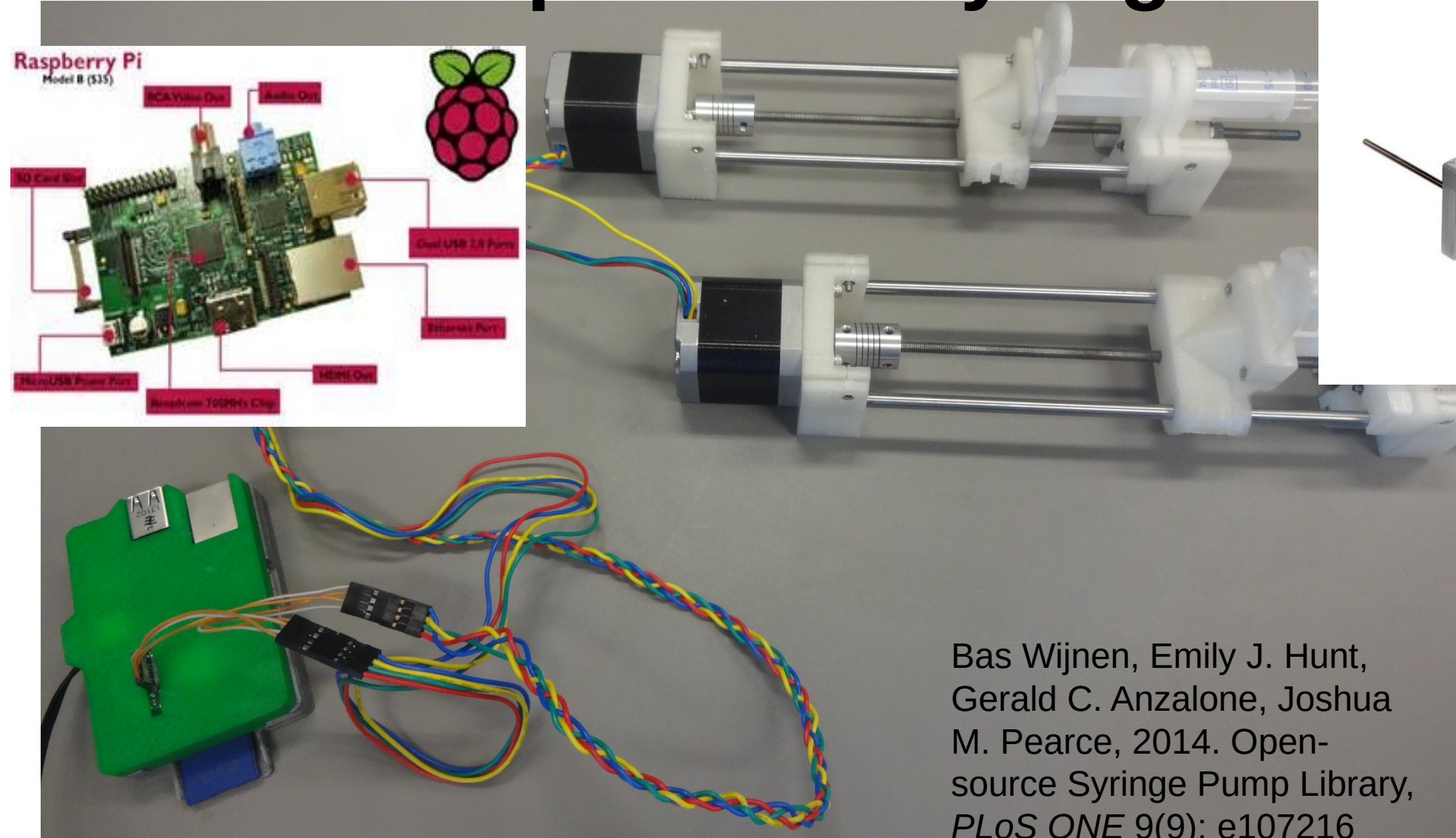
J.M.Pearce. Economic Savings for Scientific Free and Open Source Technology: A Review. *HardwareX* 8, 2020, e00139. <https://doi.org/10.1016/j.ohx.2020.e00139>





# Making Tools for Every Application

## Bespoke OS Syringe Pumps



Ville Klar, Joshua M. Pearce, Pyry Kärki, Petri Kuosmanen, Ystruder: open source multifunction extruder with sensing and monitoring capabilities. HardwareX 6 (2019) e00080.

<https://doi.org/10.1016/j.ohx.2019.e00080>

Bas Wijnen, Emily J. Hunt, Gerald C. Anzalone, Joshua M. Pearce, 2014. Open-source Syringe Pump Library, *PLoS ONE* 9(9): e107216







# of FOSH for Science

Syringe Pump: Savings \$153-\$2,442/pump (single,double)

Designs downloaded >1k times in month

**Downloaded Substitution Value \$168k-\$2.5m (now >\$20m)**

Assume \$30k for development, 52% overhead

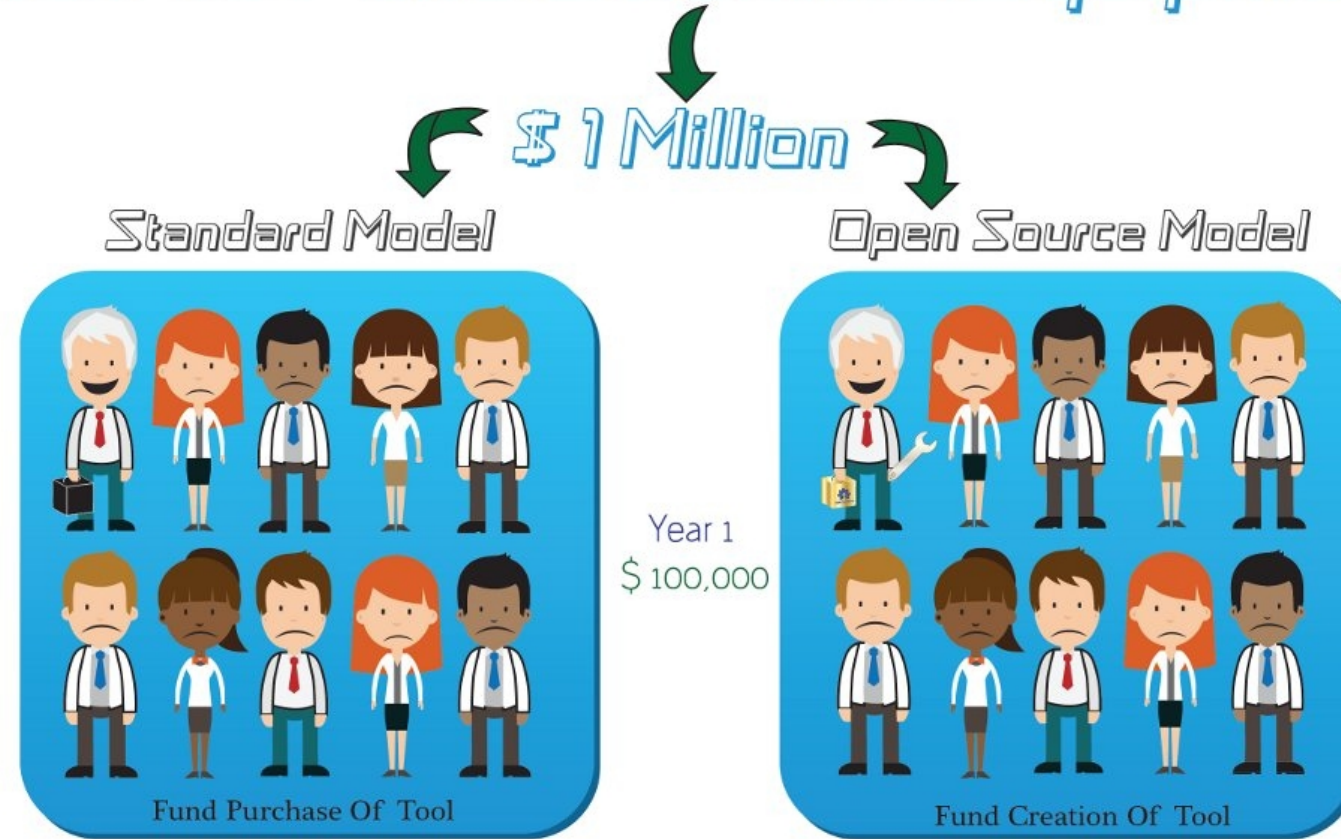
**ROI of 750%-12,000%**



J.M.Pearce. Return on Investment for Open Source Hardware Development. *Science and Public Policy* 43(2),192-195 (2016).



# How to Fund Scientific Equipment



\* Only about 10% of NSF and NIH grants are funded

FAST



Black Box Proprietary  
Scientific Hardware  
No Control



Open Source  
Scientific Hardware  
Equivalent



Open Source  
Hardware  
Design



Open innovation  
results in better  
performance

\* Open source scientific hardware costs ~10% of proprietary hardware (Pearce, J.M. Open Source Lab, Elsevier, 2014).



# Proprietary



Year 2  
\$ 100,000



Year 3 to 10  
\$ 100,000  
per year

# FOSH







*Proprietary*

**Open Source Savings**

*Open Source  
Hardware (OSH)*



Only 10 scientists funded for 10  
tools, most out of date.

90% of scientists  
remain unfunded.



91% of scientists funded, 91 state-of-the  
art research tools, all open and easily  
upgrade-able for the cost of materials



# Open Source Endowed Chairs

- **Terms**

- Demonstrated excellence in their field
- Ensuring all of their writing is distributed via open access
- Releasing all of their intellectual contributions in the public domain or under OS licenses.

- **Results**

- 81.1% Canadian faculty willing to accept the terms of an OS endowed professorship.
- 34.4% of these faculty would require no additional compensation.
- Favor receiving funds that would help benefit research (28% for graduate assistants or 46.7% for a discretionary budget)
- **In Canada: widespread shared sentiment in favor of knowledge sharing and that open source endowed professorships would be an effective way to catalyze increased sharing.**



Joshua M. Pearce, Shardul Tiwari,  
Alexis S. Pascaris & Chelsea Schelly.  
Canadian Professors Views on  
Establishing Open Source Endowed  
Professorships. Under Review



# OS Endowed Chairs in the US?

- **American university professors** show that a **super majority** (86.7%) of faculty respondents indicated willingness to accept an **OS endowed professorship**
- Only 13.3% of respondents unwilling
- Results demonstrate a willingness of American academics to expand open access to science, which would hasten scientific progress while also making science more just and inclusive.
- **It is clear that science funders have a large opportunity to move towards open science by offering open source endowed chairs.**



Joshua M. Pearce, Alexis S. Pascaris & Chelsea Schelly. Professors Want to Share: Preliminary Survey Results on Establishing Open Source Endowed Professorships(under review).





## CONTACT US

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# OS Opportunities to Maximize ROI in Research Funding



- All public funded science should be open access – OA mandates national/Uni



- All public funded research should be released under open source licenses – software and hardware - national/funder



- Strategic Uni/ National/ International investment in OS research

- Fund OS Development – - Uni/Funders/National

John M. Thompson Innovation Fund

- Fund OS Endowed Chairs - Uni/Funders/National





# Collaboration? Fully Funded PhD?



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