SP.718 Special Topics at Edgerton Center: D-Lab Health: Medical Technologies for the Developing World
Spring 2009

Massachusetts Institute of Technology

D-LAB HEALTH
sp 718/755

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Course Guide

- Overview
- Grading
- Trip
- Projects

Course Goals

- Learn about the distinctive medical challenges of the developing world
- Learn to identify medical improvisations in the field
- Learn hands-on prototyping and medical design skills
- Learn how to address safety, regulatory, and ethical challenges in device design

Class Attendance Expectations

- Lectures (PowerPoint) will be posted on web-site after the fact
- You must attend lectures- PowerPoint bullets don't contain
  - Background
  - Discussion
  - Q and A
  - Contex

Nature of the Course

- Lectures
- Material Discussion
- Hands-on work
- Teamwork
- Grading
  - Class participation and attendance 20%
  - Homework assignments 15%
  - Lab notebooks and assignments 25%
  - Presentations and design reviews 25%
  - Final design/prototype 15%

Focus of our class are devices. The following are not the purpose:

- To teach you CAD tools
  - Though rapid prototyping tools are available
- Formal Methods -Semi-quantitative, qualitative Analysis-
- Product optimization algorithms
- To study deeply the causes of poverty
- To learn advanced clinical methods for developing world medicine
- To learn how to design health systems

Resources

- Stellar
- D-Lab Site

- Office Hours
- Mentors

- D-Lab
- Edgerton Center

The Context…

D-Lab Philosophy

The Three Revolutions of Development

Appropriate Technology

Photo removed due to copyright restrictions.
Mohammed Bah Abba with the "pot in pot" earthenware cooling system.
See http://rolexawards.com/en/the-laureates/mohammedbahabba-home.jsp

Treadle pump

Photo courtesy of Alfinio Flores.
Used with permission.

Charcoal from agricultural scrap

Photo courtesy of Amy Smith.
Used with permission

Participatory Development

- Working with communities to identify problems
- Stakeholder analysis

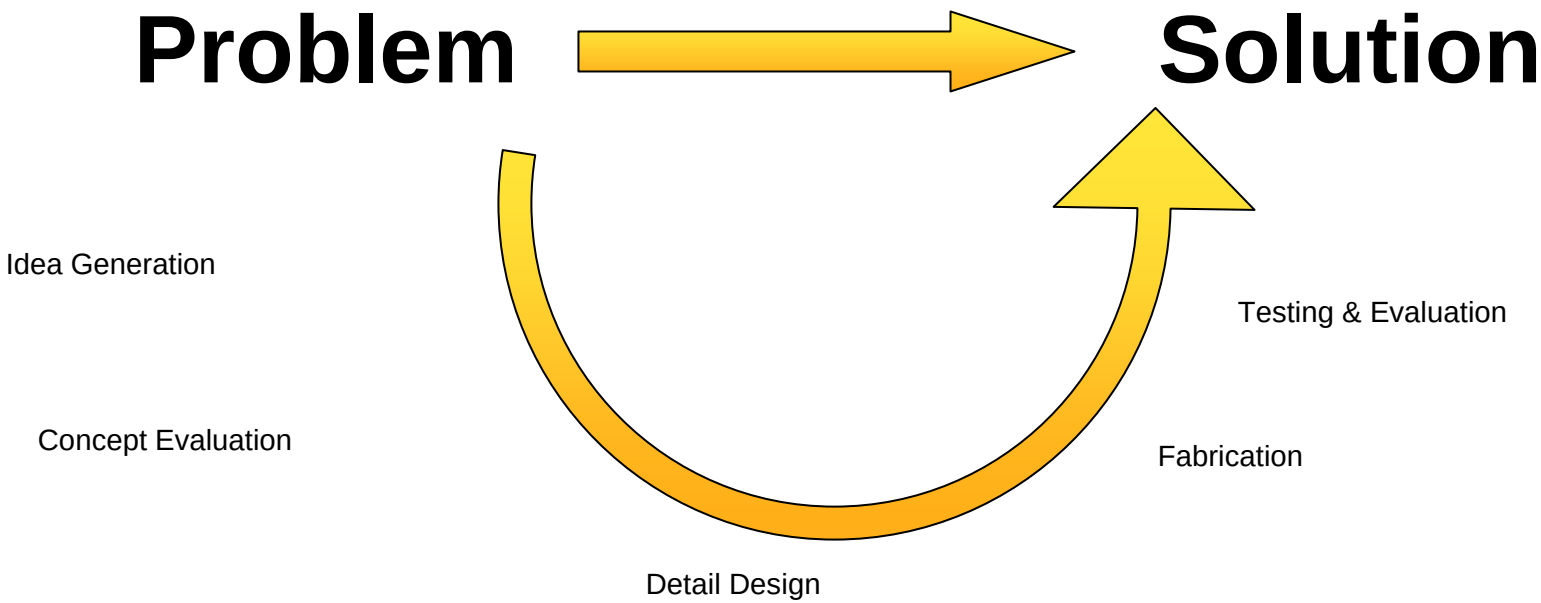
Courtesy of Amy Smith. Used with permission.

Co-creation

Courtesy of Roger Sipitakiat. Used with permission.

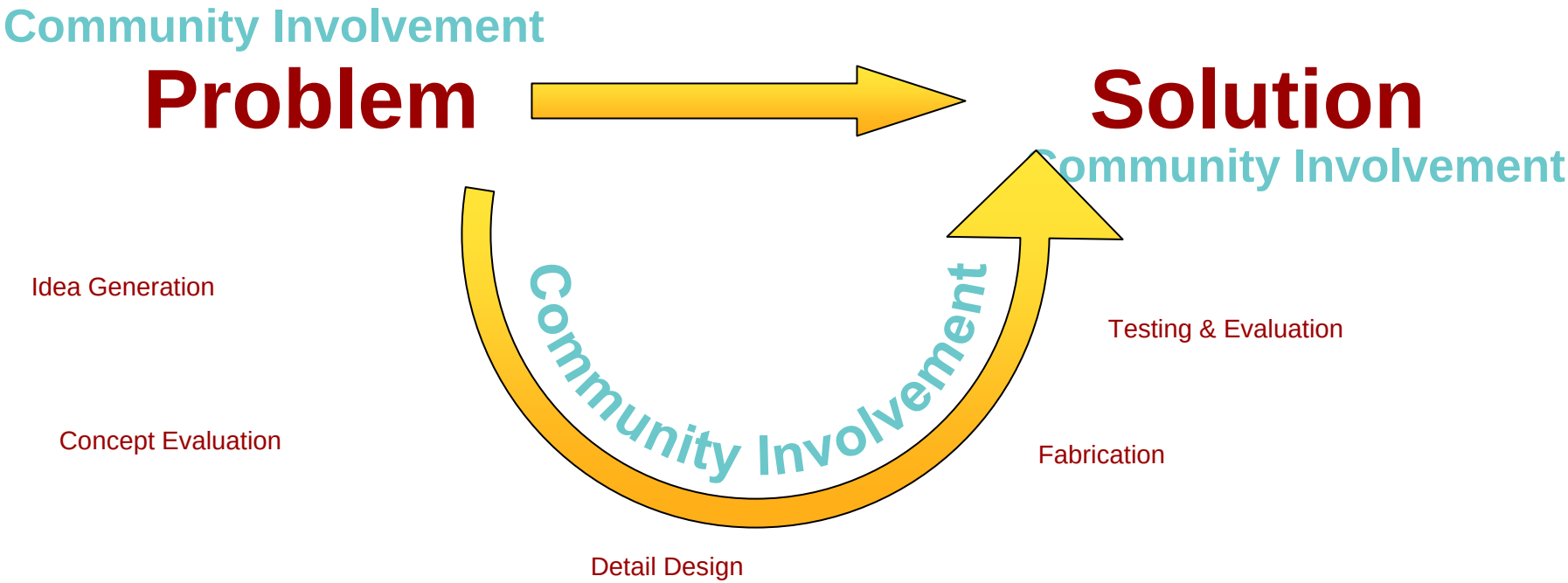
Courtesy of Roger Sipitakiat. Used with permission.

The Design Process



Courtesy of Amy Smith. Used with permission.

Consultation vs Co-Creation



Courtesy of Amy Smith. Used with permission.

Guiding Principles for D-Lab

- Identify functional requirements
- Encourage participatory development
- Value indigenous knowledge
- Promote local innovation
- Strive for sustainability

What makes D-Lab D-Lab?

- Real projects for real people
- Participation and co-creation
- Opportunities for continuation

What is Global Health?

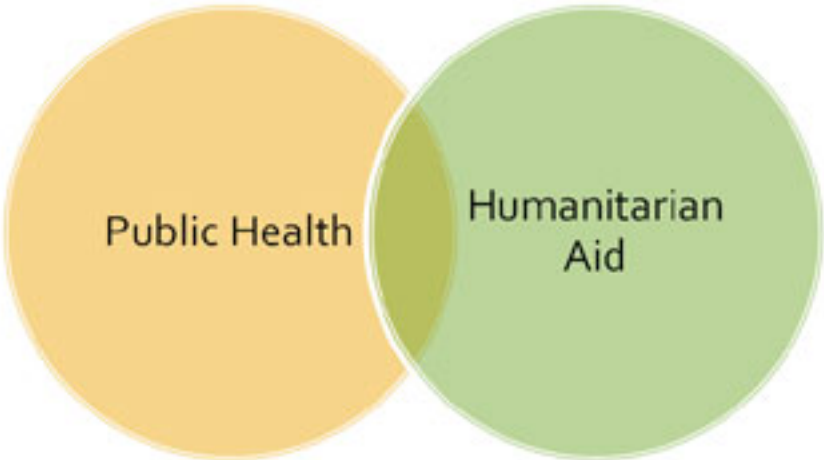
"The health problems, issues, and concerns that transcend national boundaries, may be influenced by circumstances or experiences in other countries, and are best addressed by cooperative actions and solutions."

Institute of Medicine
of the National Academies

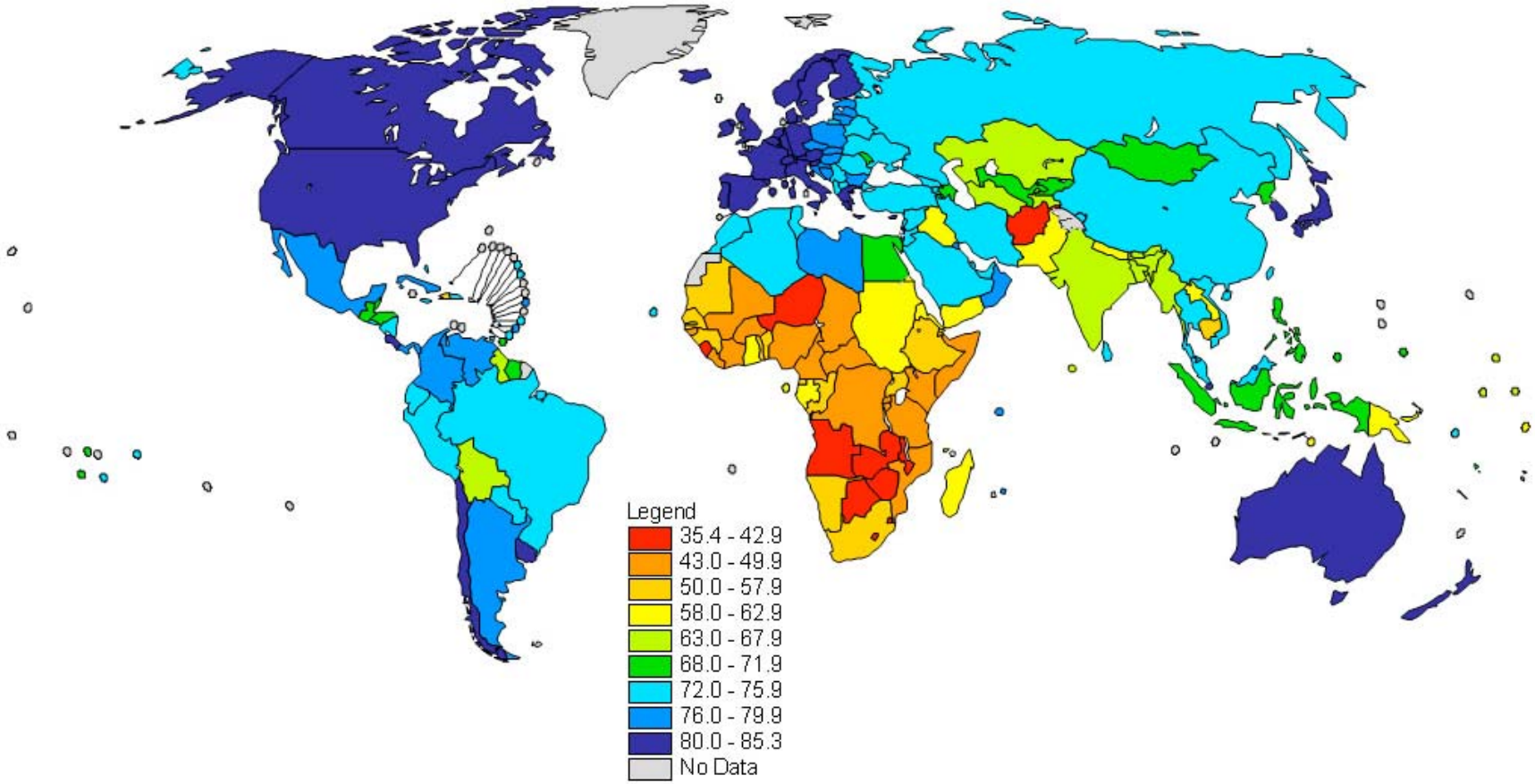
Global Health Operating Theater

Photos of health facilities around the world (hospitals, clinics, etc.) removed due to copyright restrictions.

Photos of disaster response medicine removed due to copyright restrictions.



Life Expectancy



Life expectancy at birth, females, 2003 data. From http://www.who.int/whr/maps/en/index1.html, accessed October 2009. Courtesy of the World Health Organization. Used with permission.

The Burden of Disease

Disability Adjusted Life Years

The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

The Burden of Disease

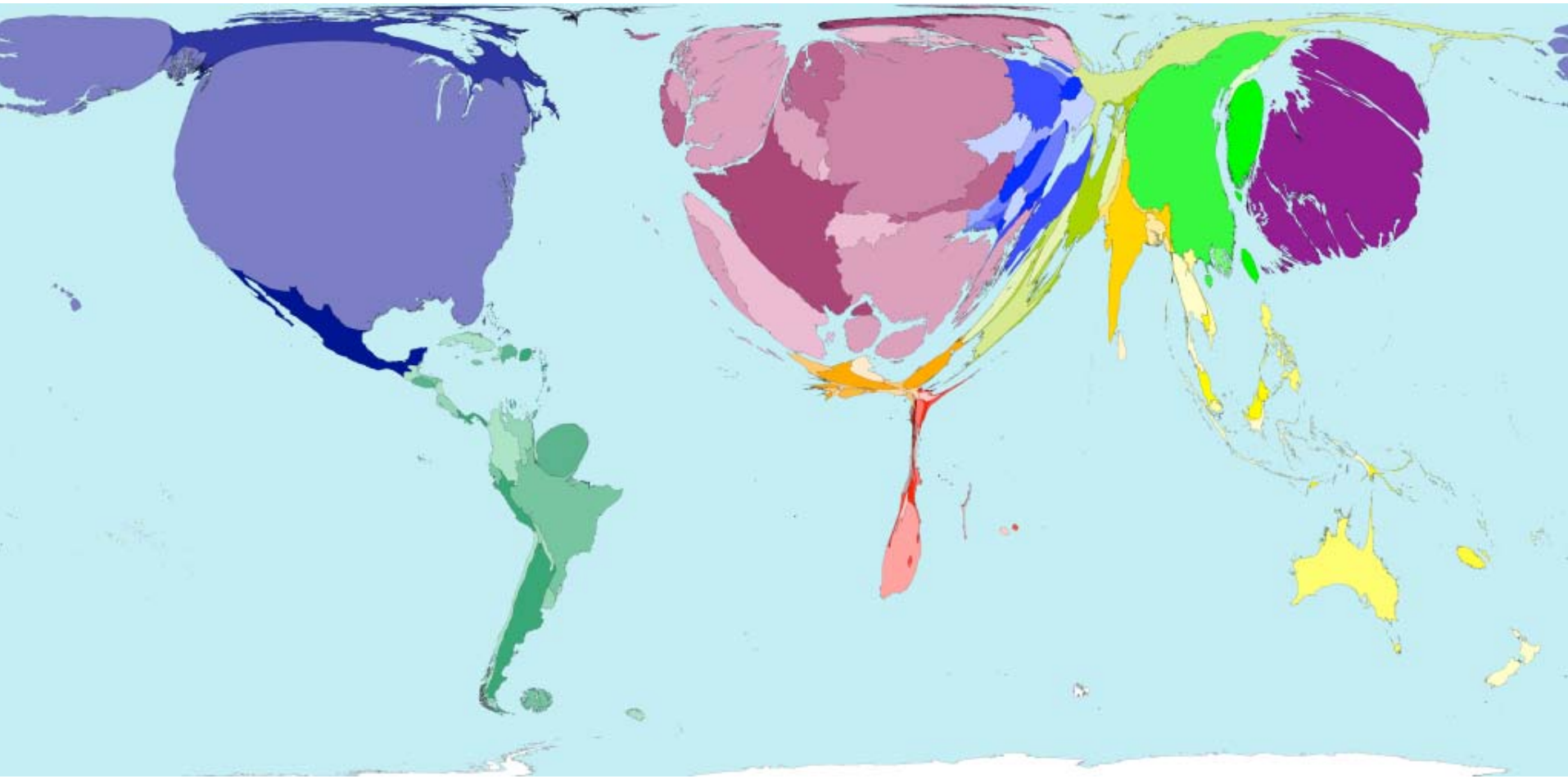
Mortality

		%
1.	Ischaemic heart disease	12.2
2.	Cerebrovascular disease	9.7
3.	Lower respiratory infections	7.1
4.	COPD	5.1
5.	Diarrhoeal diseases	3.7
6.	HIV/AIDS	3.5
7.	Tuberculosis	2.5
8.	Trachea, bronchus, lung cancers	2.3
9.	Road traffic accidents	2.2
10.	Prematurity, low birth weight	2.0

DALYs

		%
1.	Lower respiratory infections	6.2
2.	Diarrhoeal diseases	4.8
3.	Depression	4.3
4.	Ischaemic heart disease	4.1
5.	HIV/AIDS	3.8
6.	Cerebrovascular disease	3.1
7.	Prematurity, low birth weight	2.9
8.	Birth asphyxia, birth trauma	2.7
9.	Road traffic accidents	2.7
10.	Neonatal infections and other	2.7

Health Expenditures



Public health spending, 2004 data. © Copyright 2006 SASI Group (University of Sheffield) and Mark Newman (University of Michigan). Used with permission. For high res images, see: http://www.worldmapper.org/map_list.html.

Global Health Inequality

Between 1986 and 2001, global funding for health research rose from US$30 billion to US$106 billion, but progress towards new health tools for the poor remains insignificant.

Of 1,393 new medicines approved between 1975 and 1999, only 1% (16 drugs) was developed for tropical diseases and tuberculosis

Source: MSF

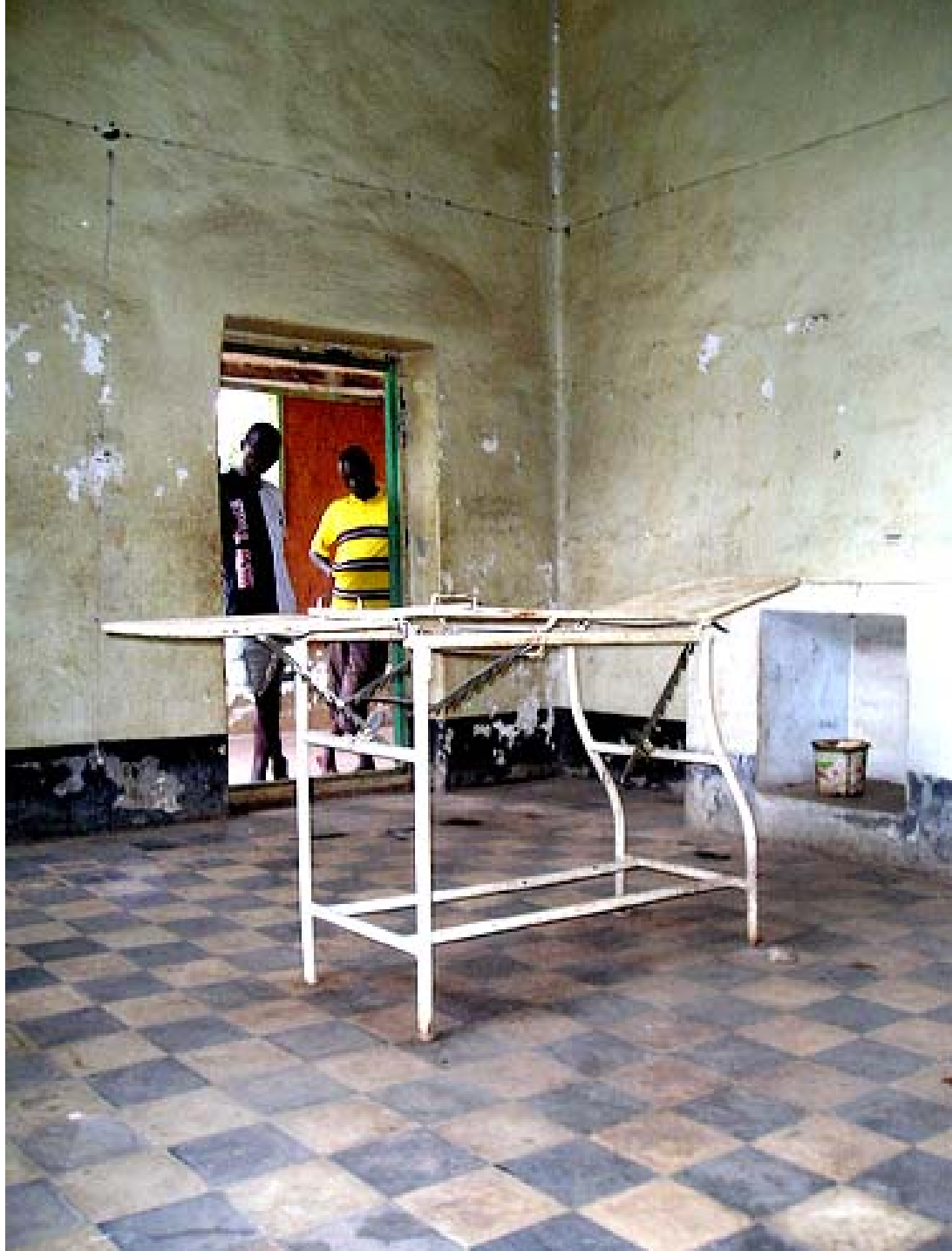
80-90%

of all medical technology in the developing world is hand-me-down equipment.

80%

of it fails within the

first 6 months.



Operating room in Sudan.
Courtesy of Teseum on Flickr.

Dual-Use Opportunities

- Dual technologies
  - Those that can be useful in developed markets, such as America, and with design parameters that can be implemented in the developing world.
- Medicines
  - Two-market pricing mechanisms
- Vaccines
  - R&D funding for disaster response to provide public health benefits
- Devices
  - DoD
  - Diaster response
  - Dedicated market opportunities

Solutions

Good News

- Many of these problems have solutions
  - Drugs (Medicine, Vaccines, Antibiotics)
  - Devices
  - Diagnostics

Bad News

- Not all of them are easy to deploy
  - Cost
  - Infrastructure
  - Education
  - Regulation

Focus tends to be on
DELIVERY SOLUTIONS
& HEALTHCARE SYSTEMS

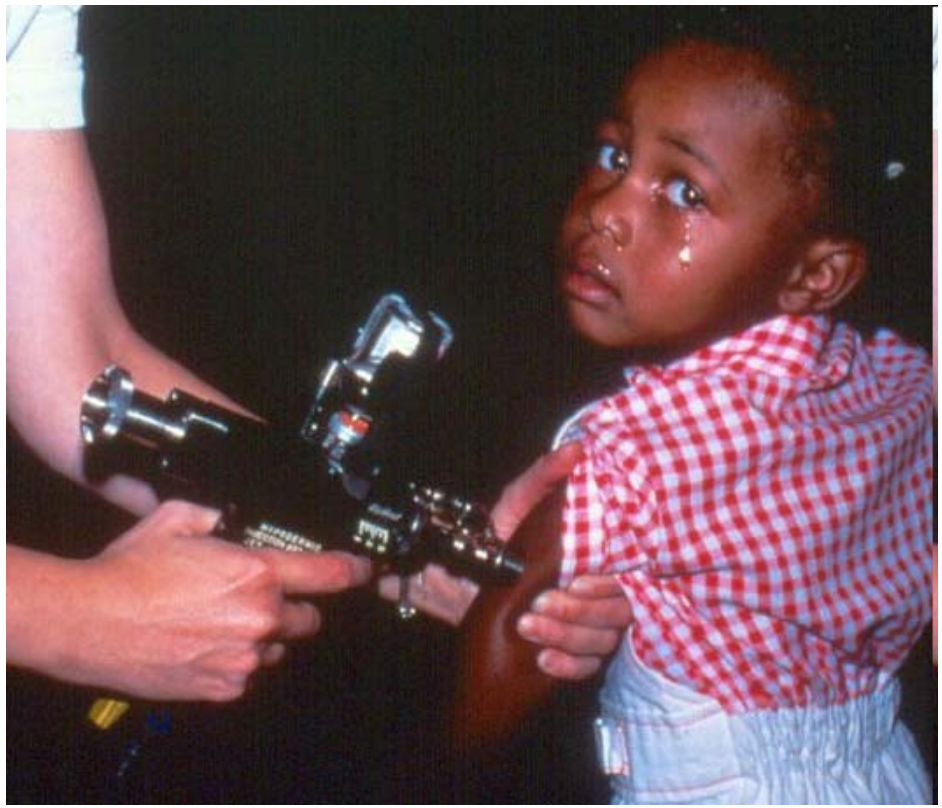
More Bad News

- Not all these problems can be addressed with available solutions
  - Cost
  - Infrastructure
  - Education
  - Addressable burden of disease disease target
  - Addressable population group

Focus tends to be on
DISCOVERY & INNOVATION

Technology Case Study

- The Jet Injector



Source: US CDC

Technology Case Study

- The Jet Injector

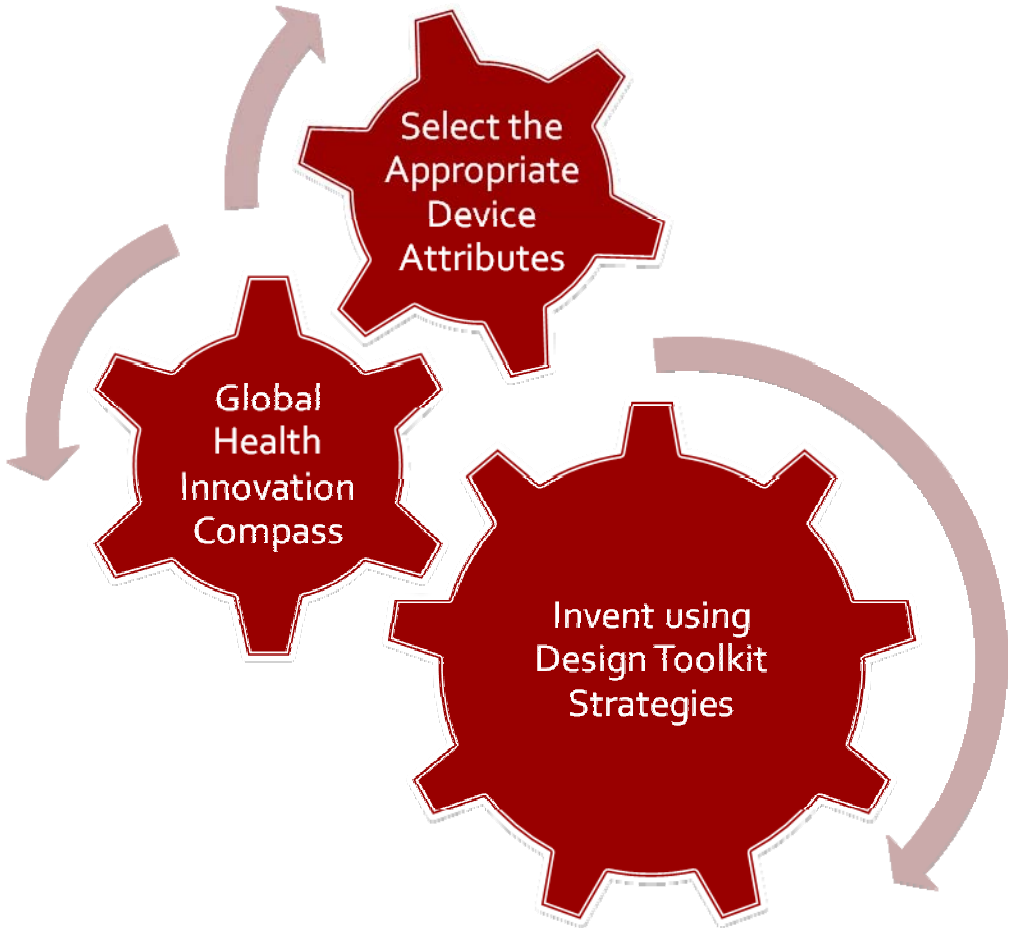
Images removed due to copyright restrictions.
Two newspaper clippings.

1)“Anti-Polio Drive Begins Sunday: City to Use Mobile Clinics and Door-to-Door Teams -- New Techniques Due.” *The New York Times*. May 18, 1961, pg. 37.

2)“’Peace Gun’ Kills Inoculation Pains: Jet Injector Can Administer Vaccines Without Needle.” *The New York Times*. October 6, 1968, p. 58.

Image removed due to copyright restrictions. Photo of MEDIVAX vaccine injector.

The D-Lab Health Design Cycle
Elements for Device Design Success



Global Health Innovation Compass

Attributes for Medical Devices

Essential	Enhancing	Long-Term
• SAFE • Accurate • Robust • Longevity • Cheap • Reliable • Reusable/Disposable	• Mobile • Connected • Smart • Plug n' Play	• Local Mfg • Local Innovation

How do we get there?
Design Strategies

- Hybridization
- Vintage Technologies + Smart Design/Tech = New Solutions
- Taking the improvisation and engineering solutions
- Bottom up observation
- Be trendsetting, not trendy
- Context shifting
- Distributed Systems
- Crowdsourcing

Hybridization

CellScope (UC Berkeley)

Figure by MIT OpenCourseWare.

Image credits: CellScope photo courtesy of Daniel Fletcher. Microscope photo courtesy of Biology Big Brother on Flickr. Cell phone drawing by MIT OpenCourseWare.

Vintage Technologies + Smart Design

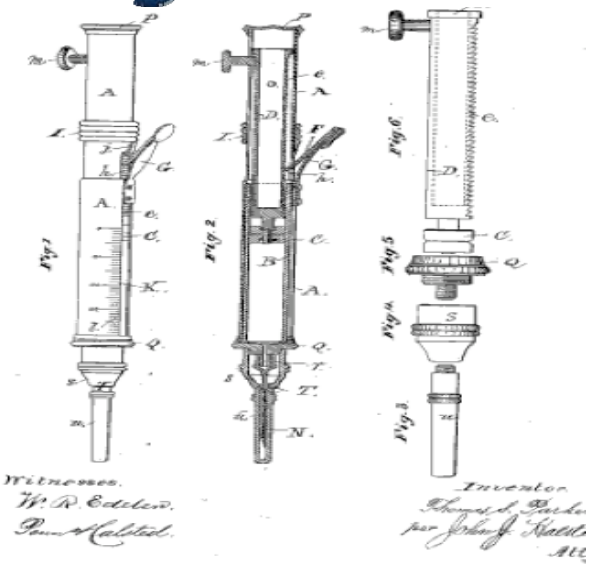


Photo courtesy of - luz - on Flickr.

Drawings of “Dragon Drug Gun” removed due to copyright restrictions.
See “New Drug-Dispensing Gun Saves Lives.” EMS House of DeFrance, June 12, 2007. Accessed 13 October 2009.
http://www.defrance.org/artman/publish/article_1838.shtml

Improvisation → Design

Photos of commercial asthma inhaler removed due to copyright restrictions. See, for example, Philips Respironics OptiChamber(R), http://optichamberholdingchamber.respironics.com/

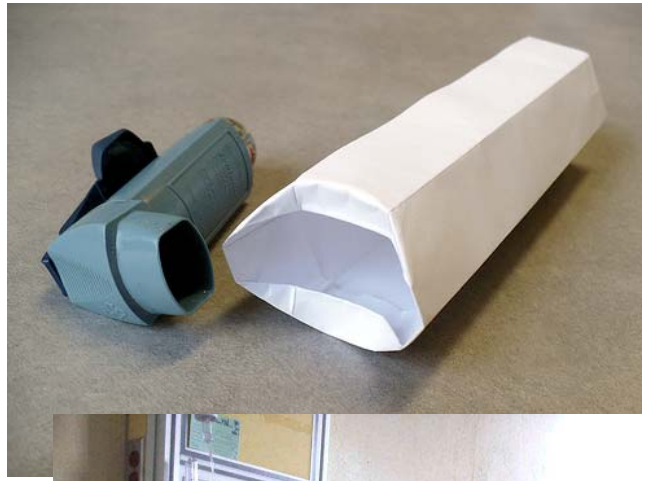


Figure by MIT OpenCourseWare.

Bottom Up Observation

Photo removed due to copyright restrictions.

Grayson Rosenberger with his “Bubble Wrap® Cosmetic Covering Shell for Artificial Legs in Developing Countries.”

Context Shifting

Photo removed due to copyright restrictions. Playpumps International water pump in action:
http://www.flickr.com/photos/playpumps/3236397277/

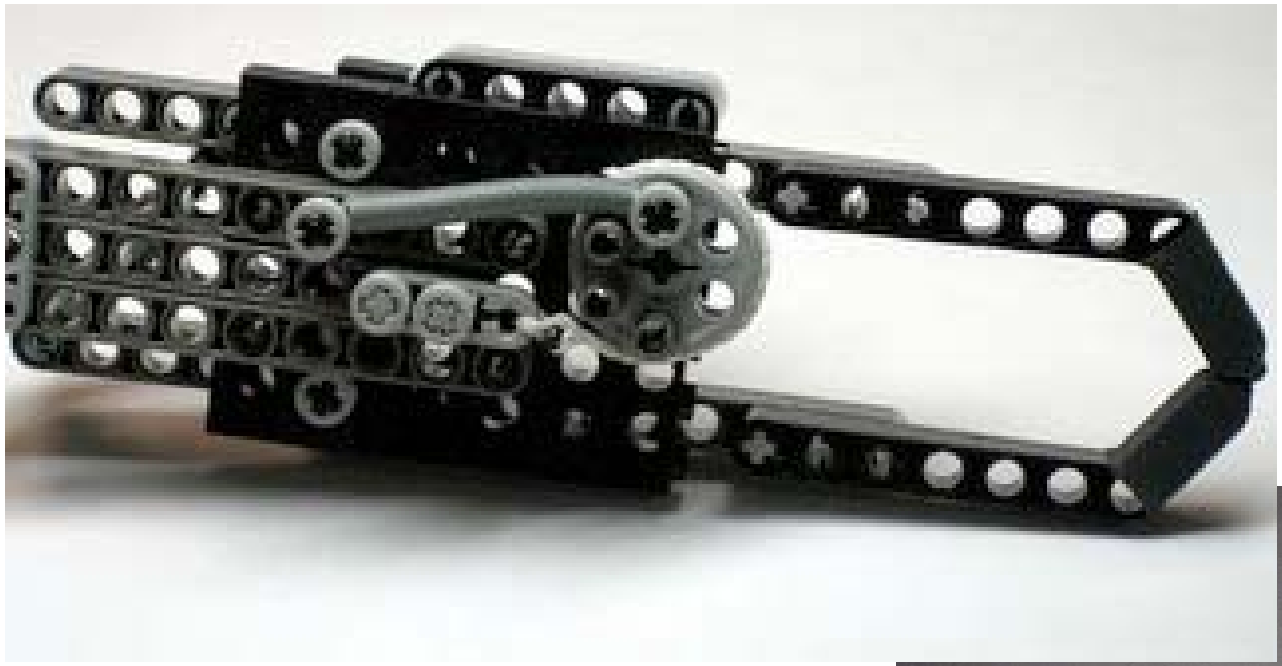
Context Shifting

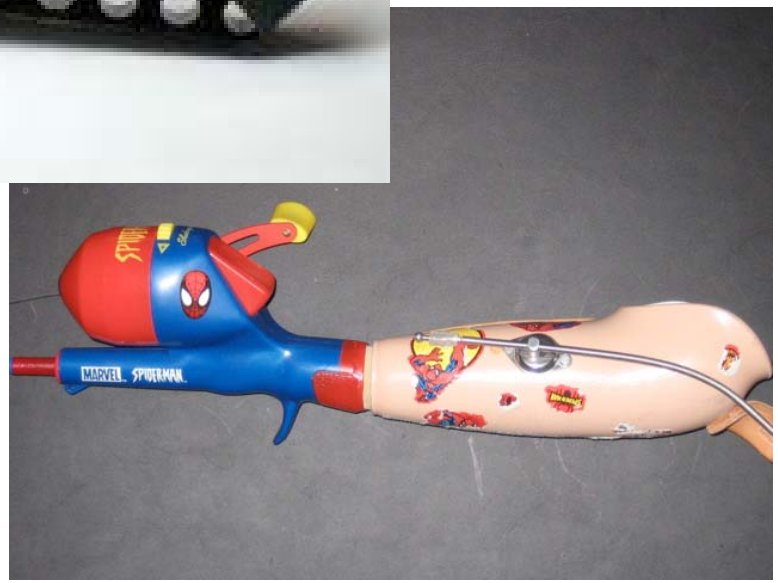
Photo courtesy of
jillig on Flickr.

Leveraging Distributed Systems

Photo of a telemedicine system removed due to copyright restrictions.
A community health worker captures images and symptoms using a cellphone, transfers the data to a server, where a doctor logs in using the internet to provide consultation and to prescribe treatment.

Crowdsourcing





Photos from Open Prosthetics Project (public domain license)
http://openprosthetics.org

Homework

- Chart out technology X
- - Asthma
- [insert devices, options, treatment staff]
- - Cardiac care
- [insert devices, options, treatment staff]

The Stage & the Actors

Policy & Aid

- WHO
- UNICEF
- Multilateral aid agencies
- MSF
- Red Cross

- Solution Side
- PATH
- FIND
- Rice, Duke,
- MIT
- CIMIT
- MedMondiale
- IAVI*
- OneWorld Health*

The Stage & the Actors

Funders

- GAVI
- Gates
- Rockefeller
- Who else?

Regulators

- MOH
- FDA
- CE

- Industry
- Social Entrepreneurs

Lab Preparation

- Please read the lab homework.

- For Monday
- Reading of Rx for Survival
- Chapter 1-2

- Case study of Auto-Destruct Syringes
- Case Study of Paper Board Spacer