M2794.006900 DESIGN FOR MANUFACTURING

Week 2, September 7

Introduction II

Fall 2017

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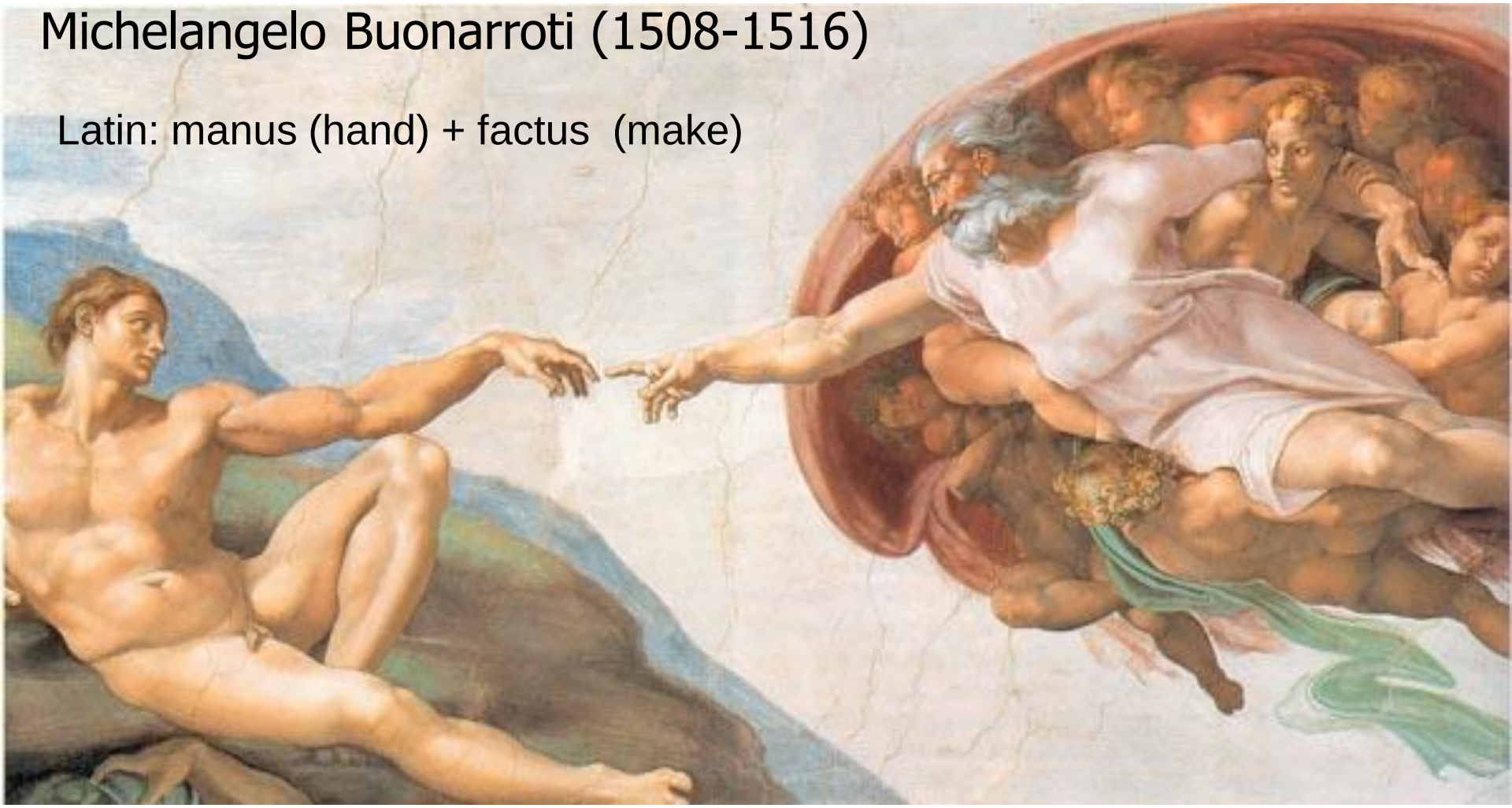
Department of Mechanical and Aerospace Engineering
Seoul National University

Outline

- **A brief history of design, material and manufacturing**
- **Issues in the 21st century manufacturing**

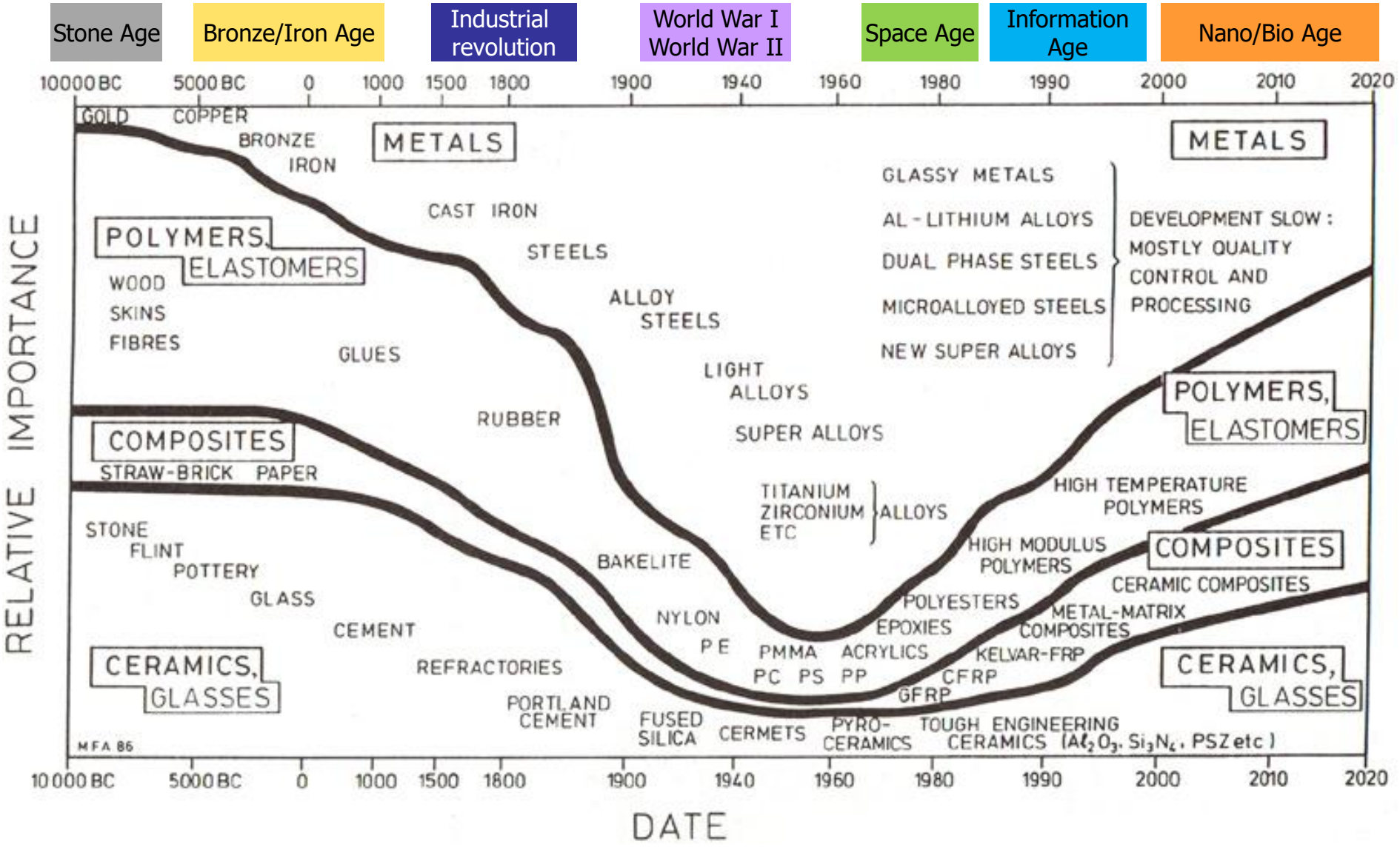
Creation of Adam



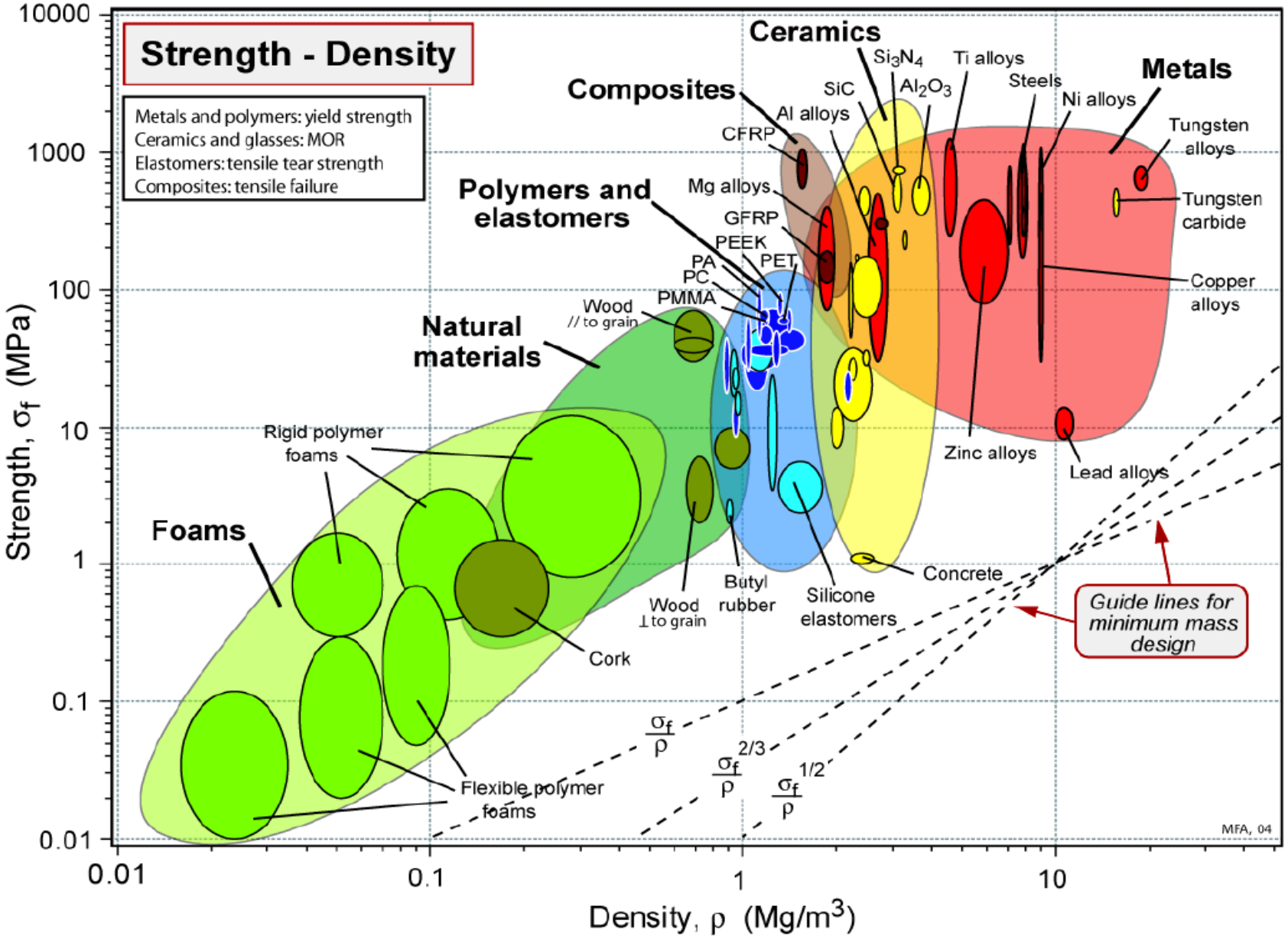
the LORD God formed the man from the dust of the ground and breathed into his nostrils the breath of life, and the man became a living being. (Genesis 2:7)

http://img.blog.yahoo.co.kr/ybi/1/9a/3d/shim4ro/folder/13/img_13_1426_1?1179585265.jpg

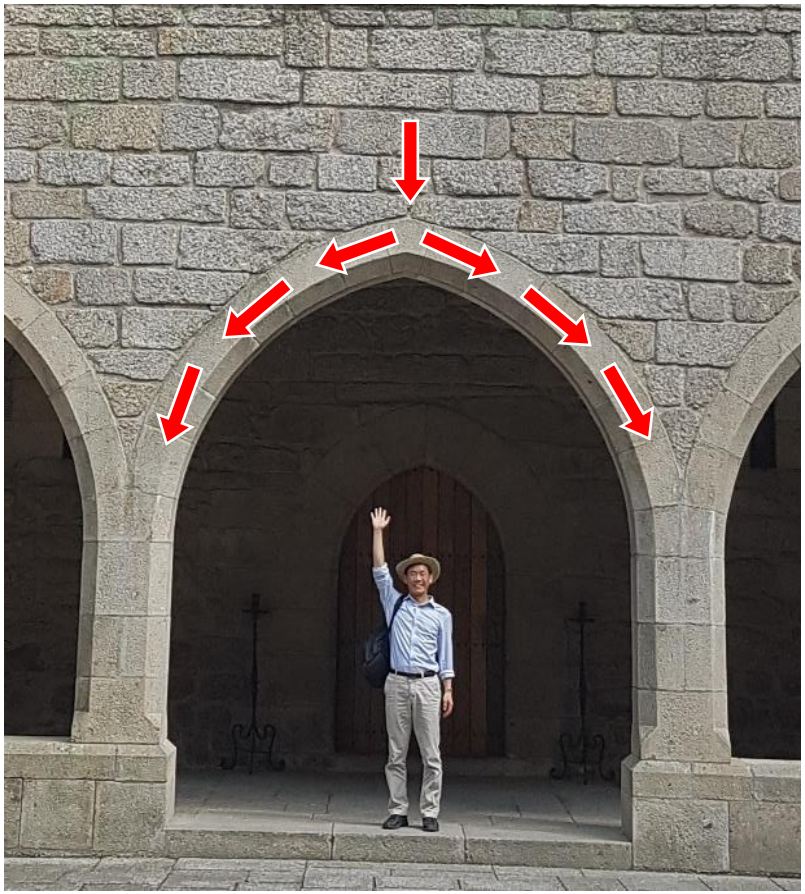
History of material usage



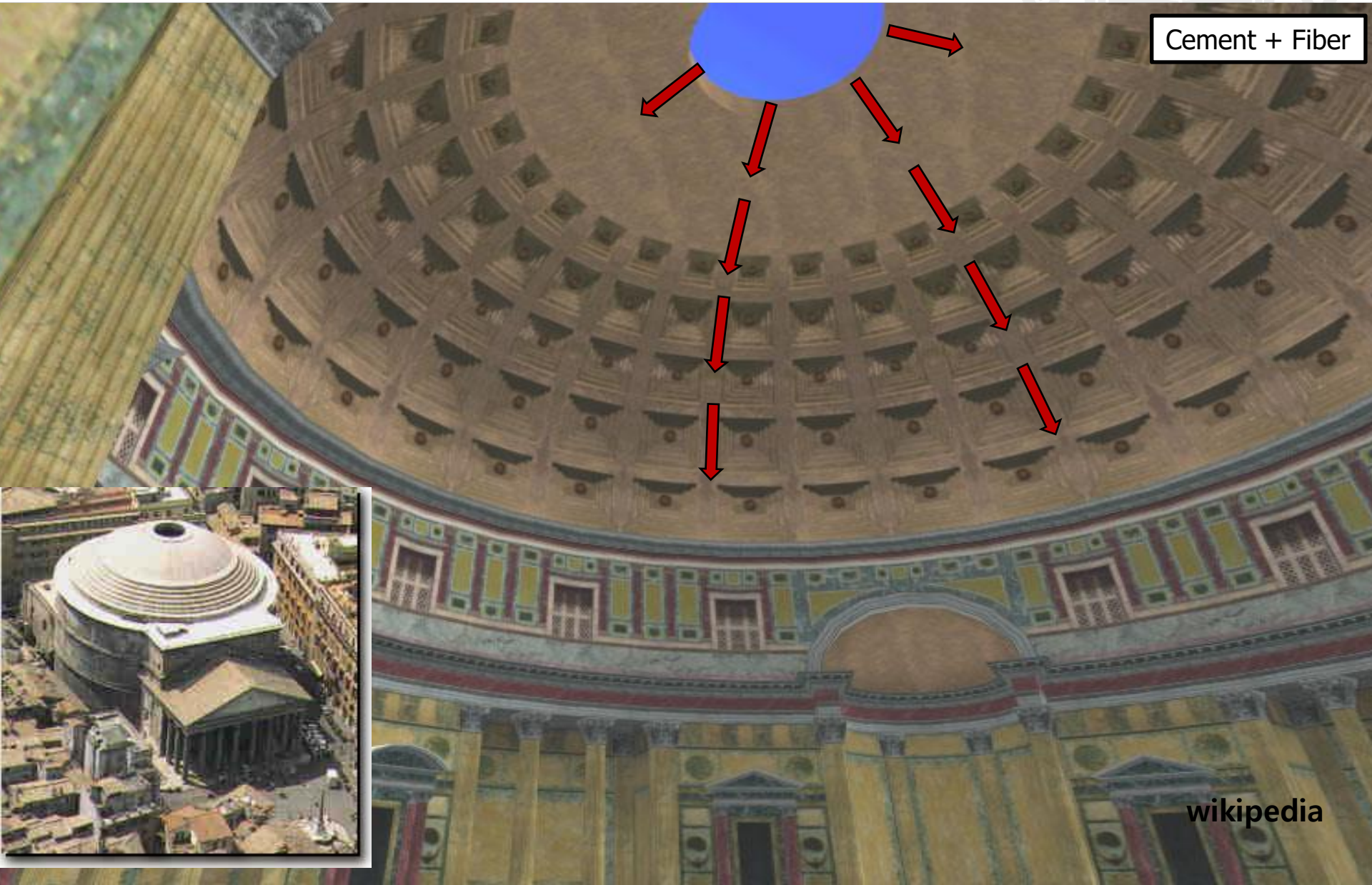
Available materials



Structures

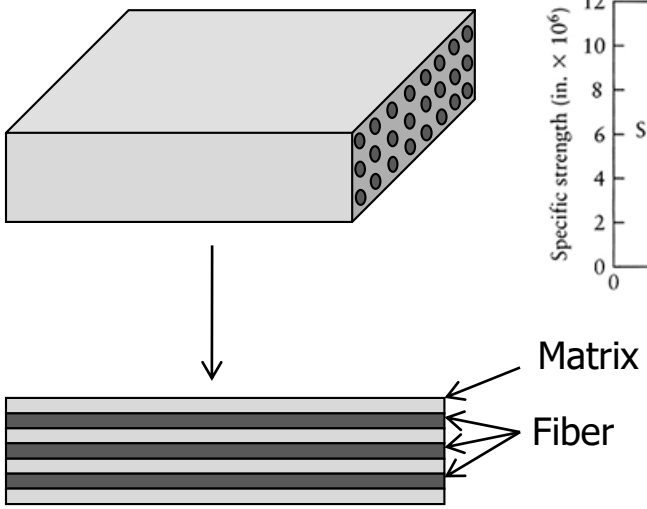


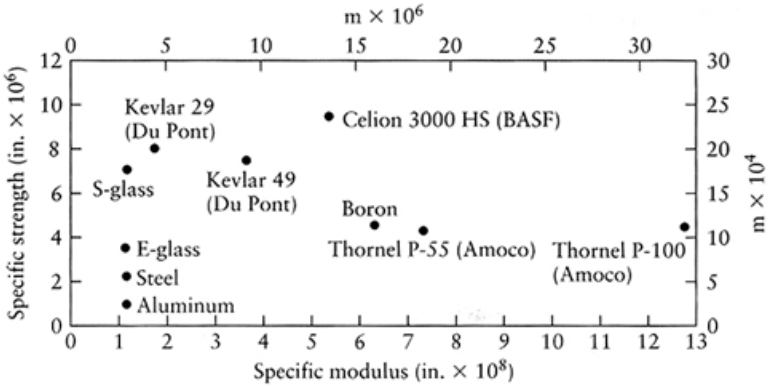
Dome of Pantheon: AD 122, Rome

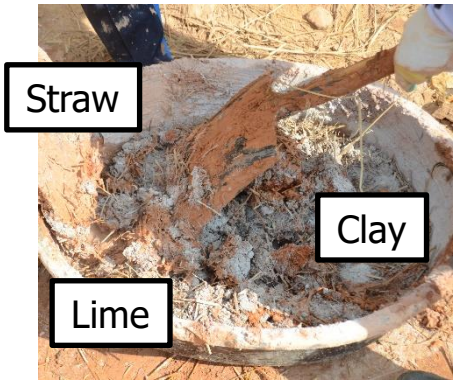


Composite materials

http://www.floweringelbow.org/



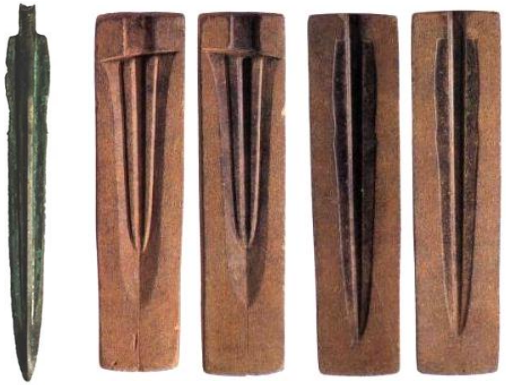




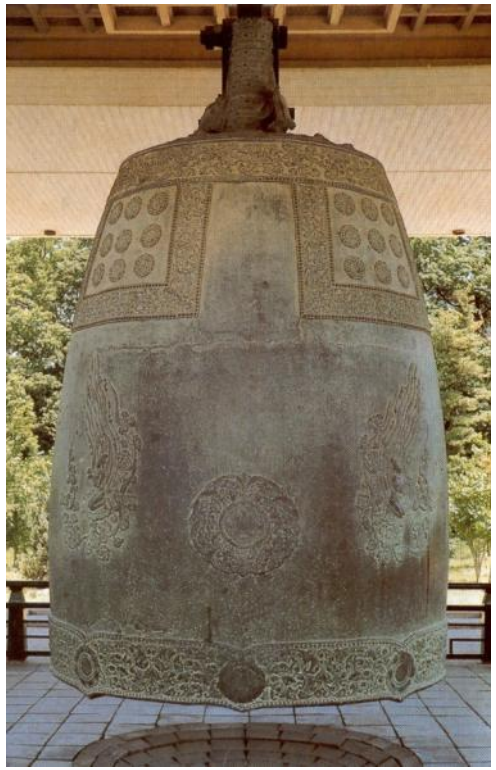
"You are no longer to supply the people (Israelite) with straw for making bricks…" *(Exodus 5:7) BC 25 C*

Automobile AD 20 C

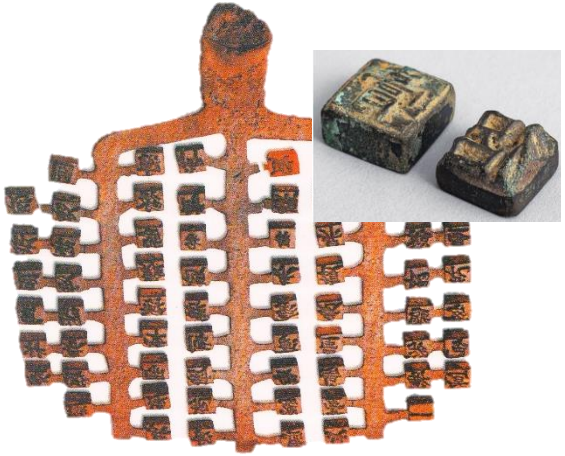
Casting



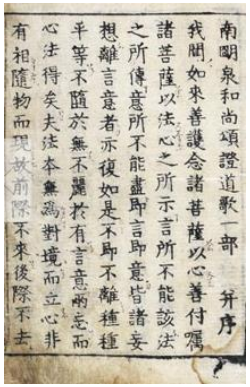
Slender bronze dagger (세형 동검, 細形銅劍)
& Mold (거푸집) BC 3C



Bell (에밀레종) AD 771



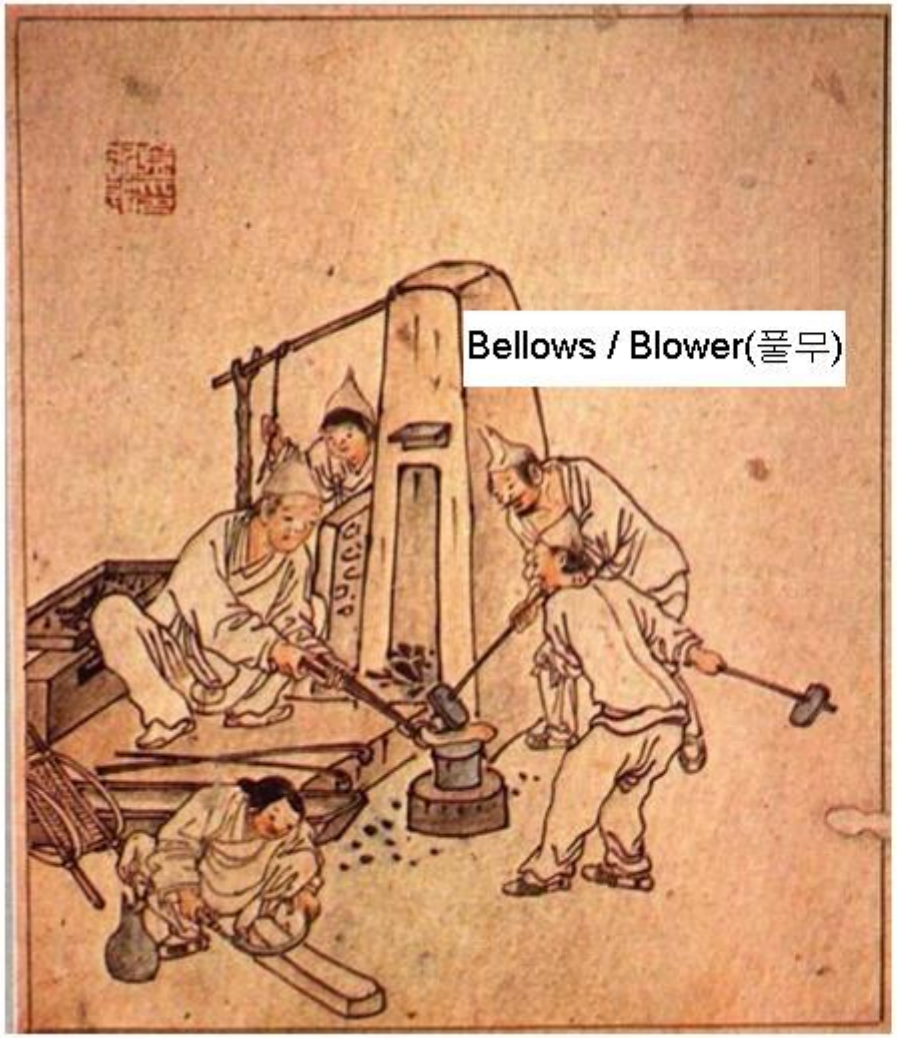
Metallic printing type (금속 활자)



남명천화상송증도가 AD 13 C

Koreans Race first used this Bronze Printing Type in 1234 and it was officially approved by the world. (cf. Gutenberg bible, AD 1400)

Forging



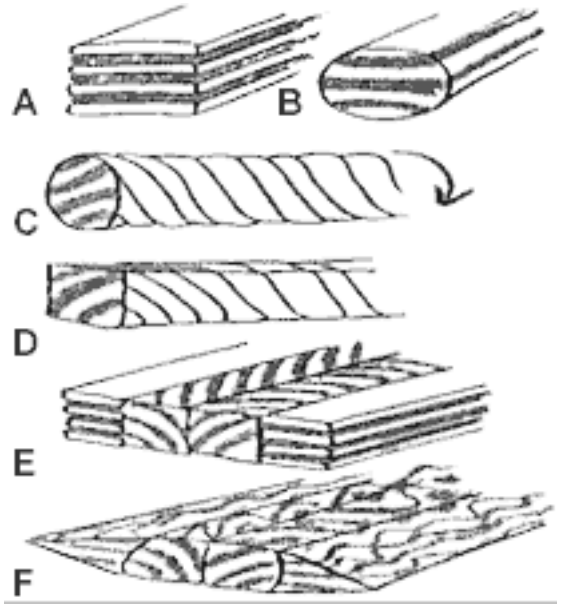
대장간_김홍도 AD 18 C

Forging machine AD 20 C

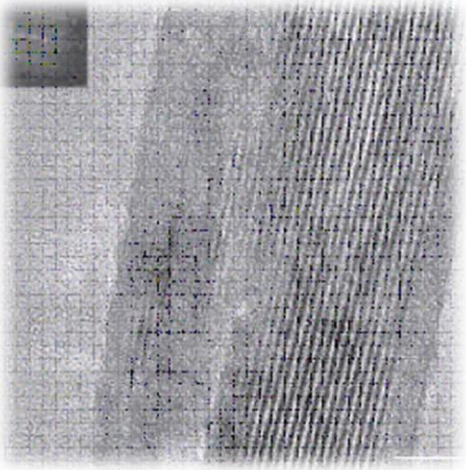
Damascus sabre (AD 3 C ~ 17 C)

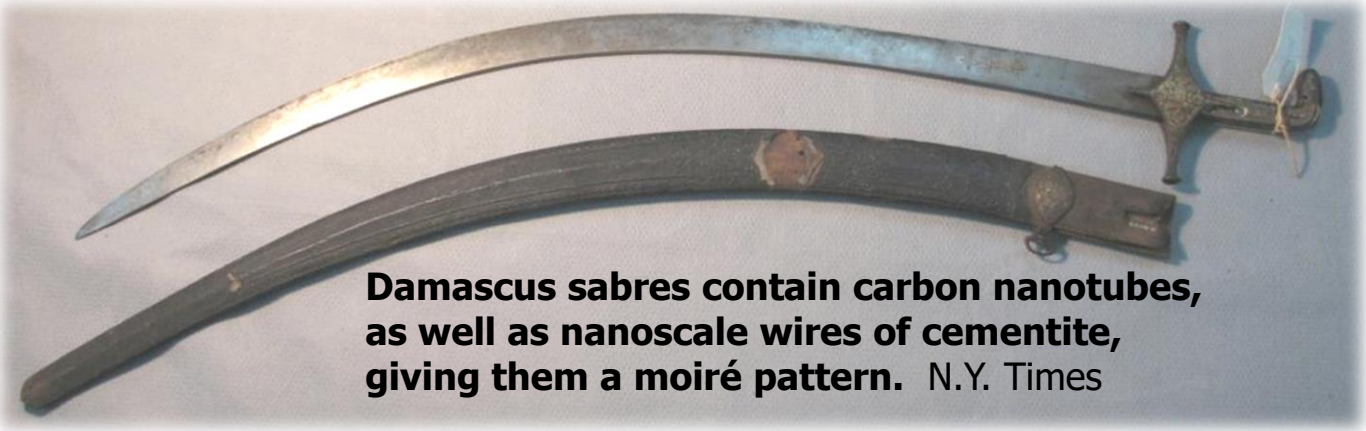
NATURE|Vol 444|16 November 2006

Manufacturing principles of Damascus steel



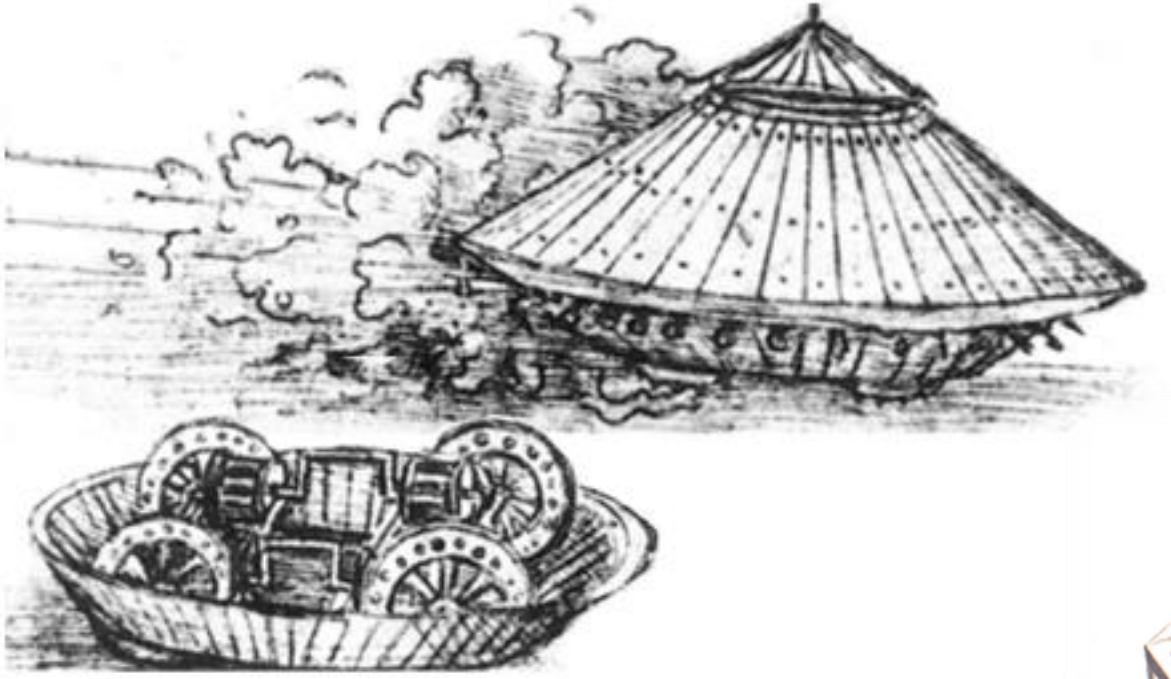
http://blog.naver.com/linuxian?Redirect=Log&logNo=60032341223



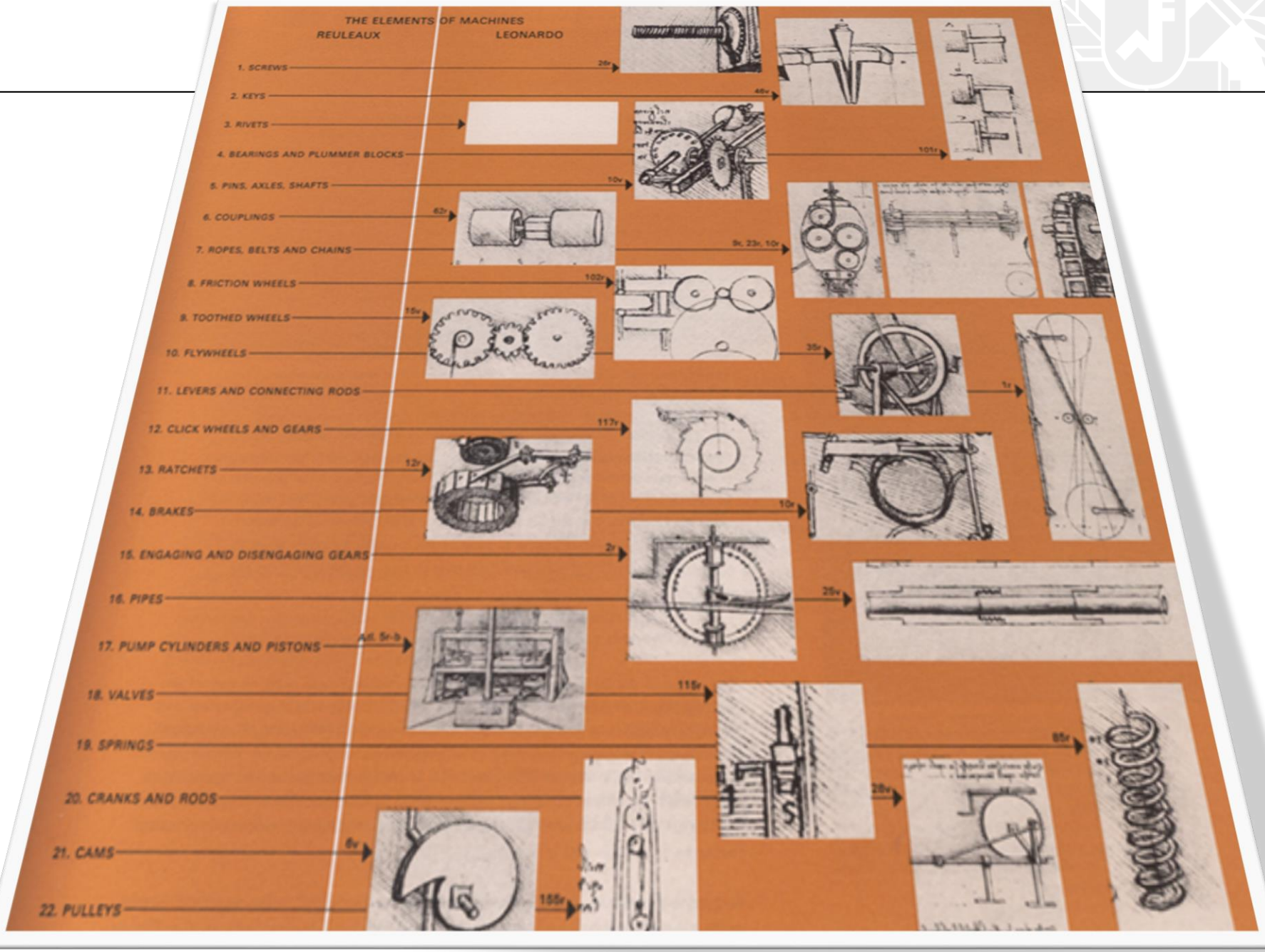


Damascus sabres contain carbon nanotubes, as well as nanoscale wires of cementite, giving them a moiré pattern. N.Y. Times

Leonardo Da Vinci AD 16 C



Can you make it?

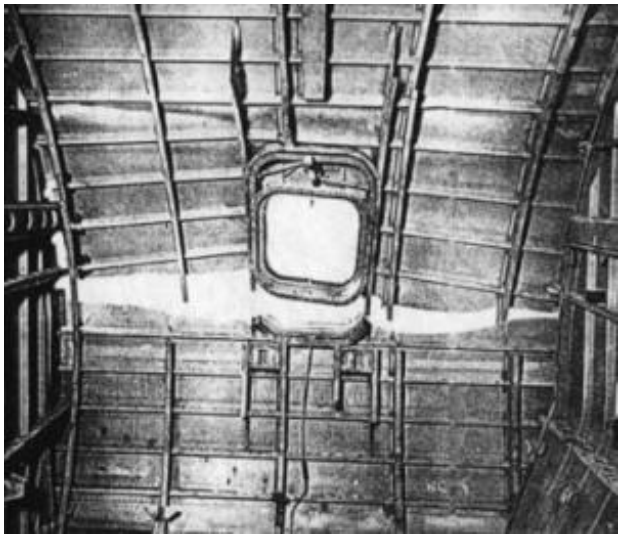

THE ELEMENTS OF MACHINES
REULEAUX
LEONARDO
1. SCREWS
2. KEYS
3. RIVETS
4. BEARINGS AND PLUMMER BLOCKS
5. PINS, AXLES, SHAFTS
6. COUPLINGS
7. ROPES, BELTS AND CHAINS
8. FRICTION WHEELS
9. TOOTHED WHEELS
10. FLYWHEELS
11. LEVERS AND CONNECTING RODS
12. CLICK WHEELS AND GEARS
13. RATCHETS
14. BRAKES
15. ENGAGING AND DISENGAGING GEARS
16. PIPES
17. PUMP CYLINDERS AND PISTONS
18. VALVES
19. SPRINGS
20. CRANKS AND RODS
21. CAMS
22. PULLEYS

Conveyer Belt

"Modern Times" (1936)

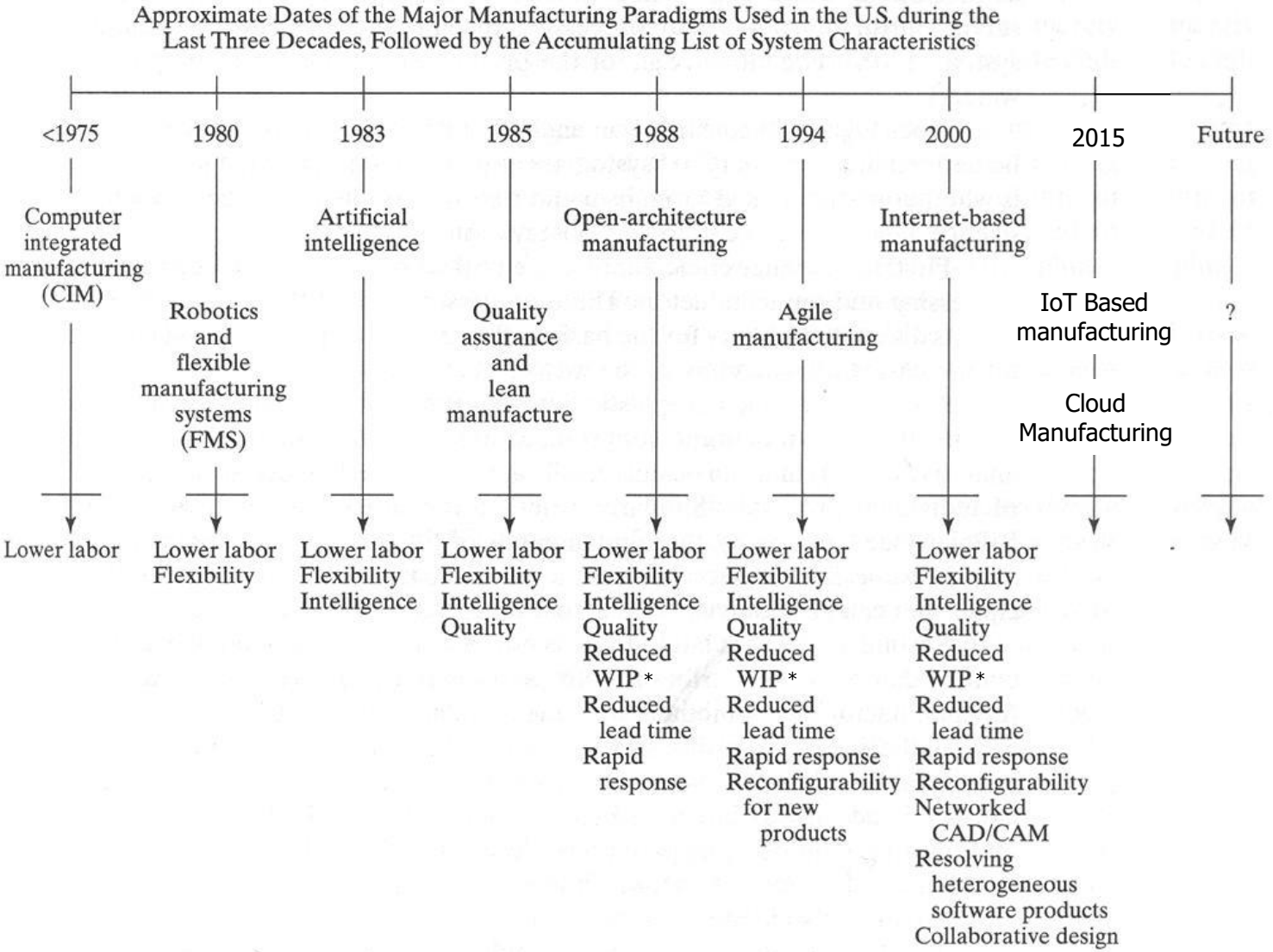
Fatigue

(1)



(2)

Modern Manufacturing:
The 1980s to the present



*WIP : Work in process

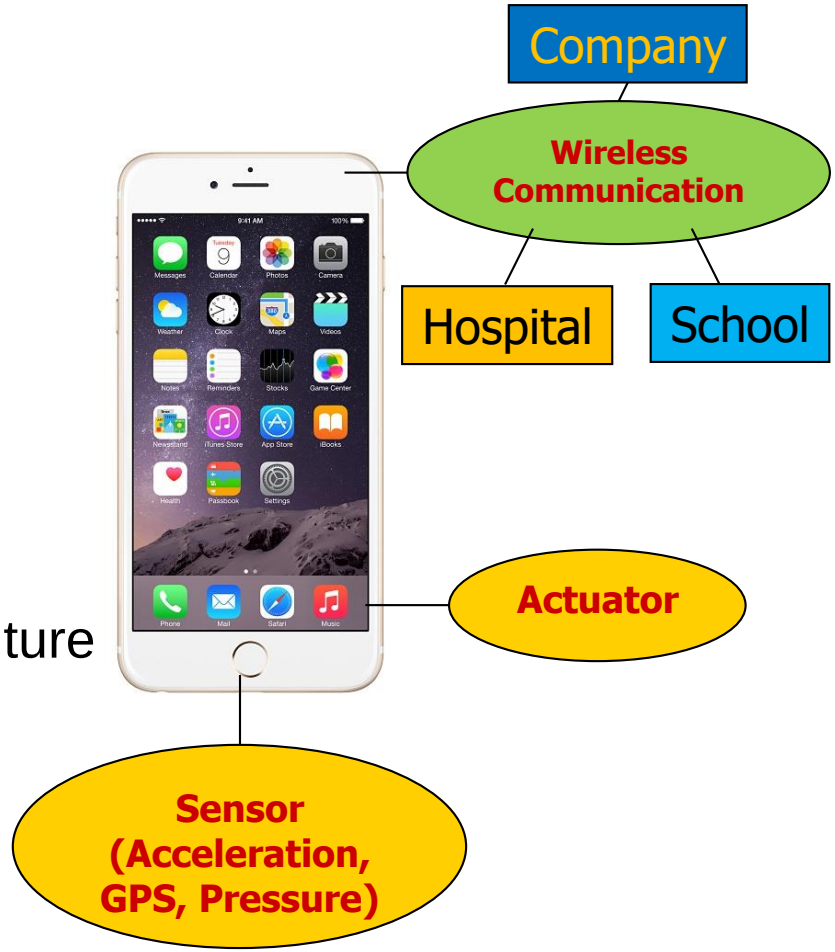
Fig 1.2 on page 14 (21st Century Manufacturing)

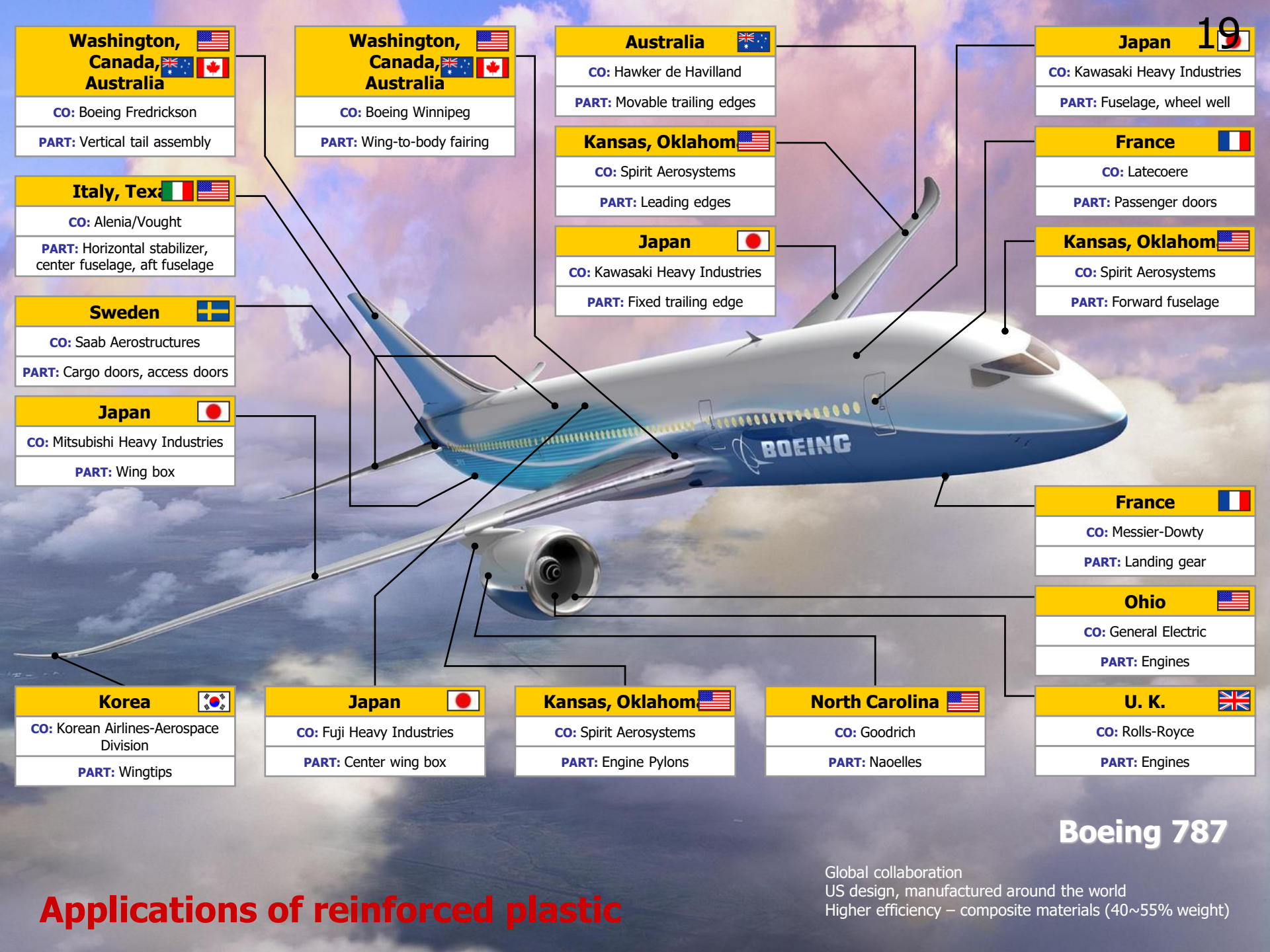
Some trends of 21st century

- **Integration of technologies**
  - IT + BT + NT + CT + DT + ??
- **Global product development**
  - Collaboration
  - Competition
- **Mass customization**
  - Personal devices
  - Adaptation of individual style and culture

From Soo Eun

Smart Phone – Phone or PC?





Washington, Canada, Australia
CO: Boeing Fredrickson
PART: Vertical tail assembly

Washington, Canada, Australia
CO: Boeing Winnipeg
PART: Wing-to-body fairing

Australia
CO: Hawker de Havilland
PART: Movable trailing edges

Japan
CO: Kawasaki Heavy Industries
PART: Fuselage, wheel well

Kansas, Oklahom
CO: Spirit Aerosystems
PART: Leading edges

France
CO: Latecoere
PART: Passenger doors

Italy, Texa
CO: Alenia/Vought
PART: Horizontal stabilizer, center fuselage, aft fuselage

Japan
CO: Kawasaki Heavy Industries
PART: Fixed trailing edge

Kansas, Oklahom
CO: Spirit Aerosystems
PART: Forward fuselage

Sweden
CO: Saab Aerostructures
PART: Cargo doors, access doors

Japan
CO: Mitsubishi Heavy Industries
PART: Wing box

France
CO: Messier-Dowty
PART: Landing gear

Ohio
CO: General Electric
PART: Engines

Korea
CO: Korean Airlines-Aerospace Division
PART: Wingtips

Japan
CO: Fuji Heavy Industries
PART: Center wing box

Kansas, Oklahom
CO: Spirit Aerosystems
PART: Engine Pylons

North Carolina
CO: Goodrich
PART: Naoelles

U. K.
CO: Rolls-Royce
PART: Engines

Boeing 787

Global collaboration
US design, manufactured around the world
Higher efficiency – composite materials (40~55% weight)

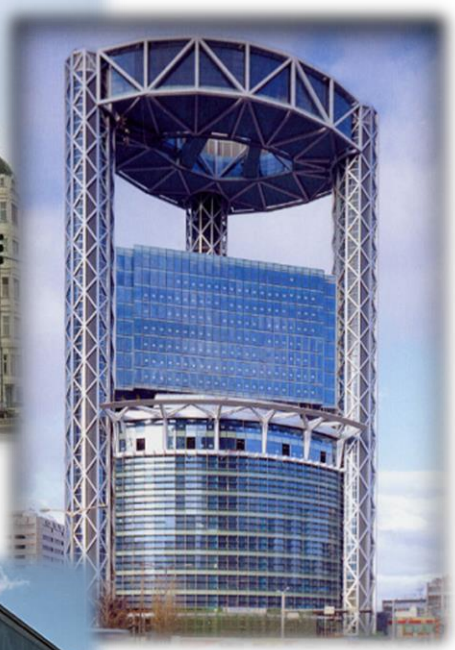
Applications of reinforced plastic

Post-modernism

Modernism

VS

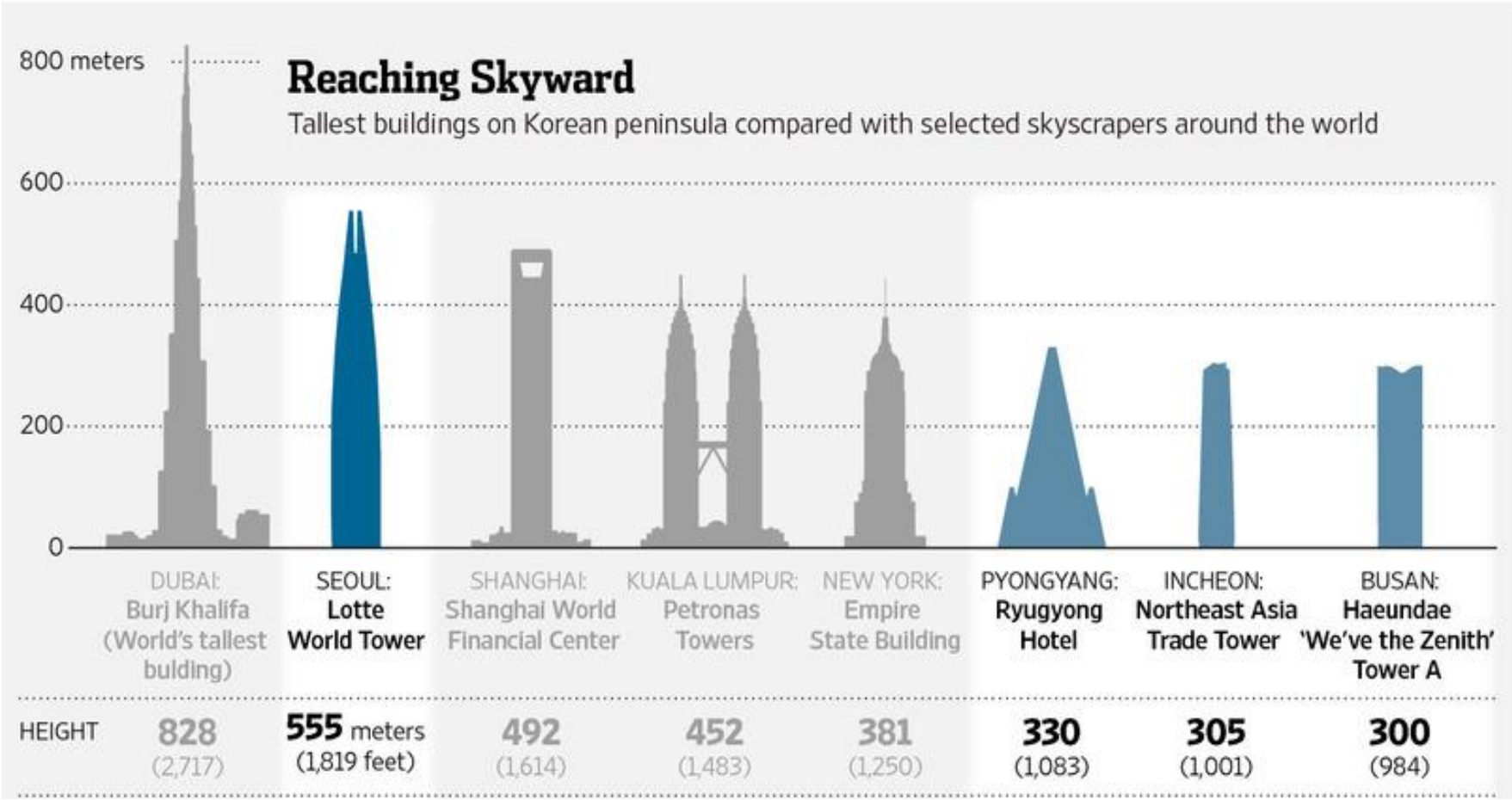
Postmodernism



Ultra Scale

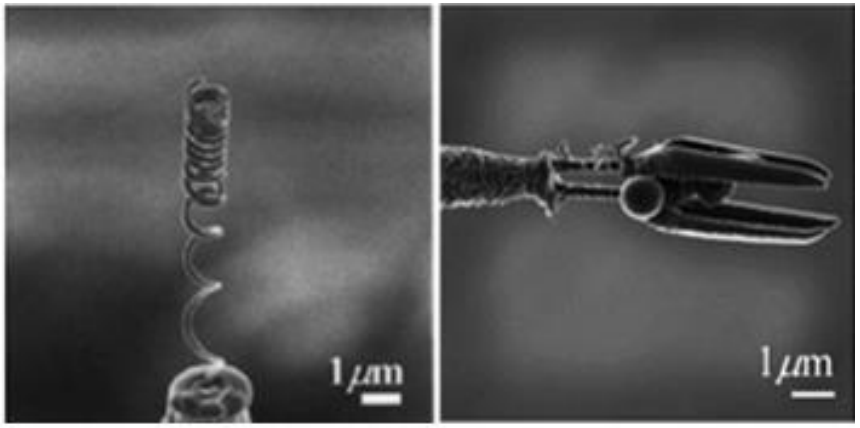
http://morewhat.com/wordpress/wp-content/uploads/2007/10/AirbusA380.jpg

http://www.dailymail.co.uk/news/article-2687728/New-Yorks-Nordstrom-Tower-tallest-residential-structure-world.html

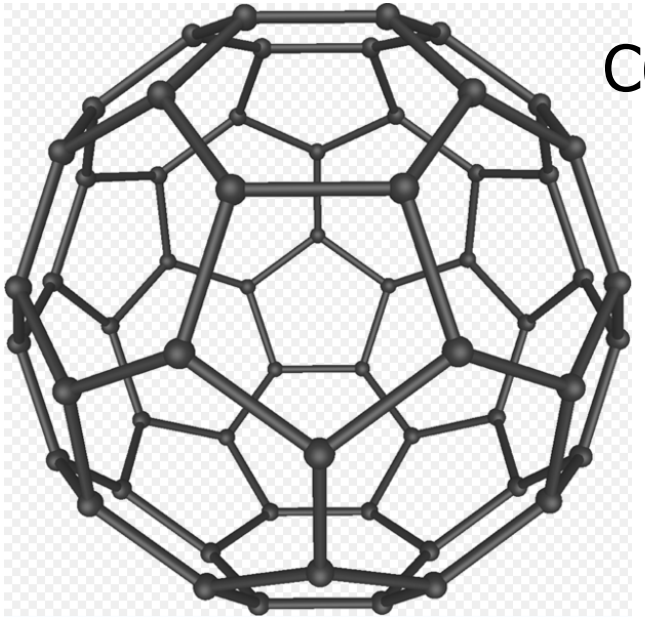


Source: Council on tall buildings and urban habitat; staff reports, The wall street journal

Small scale

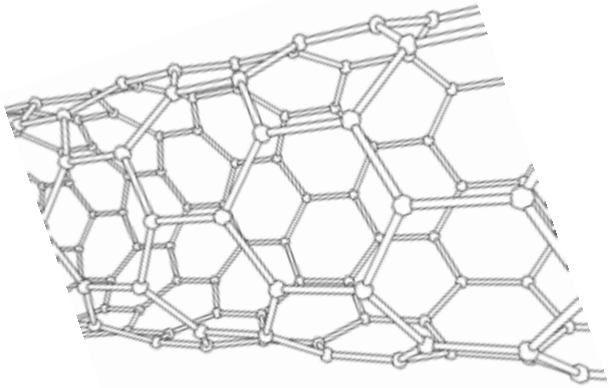


Coil-Shaped 4-Fingers



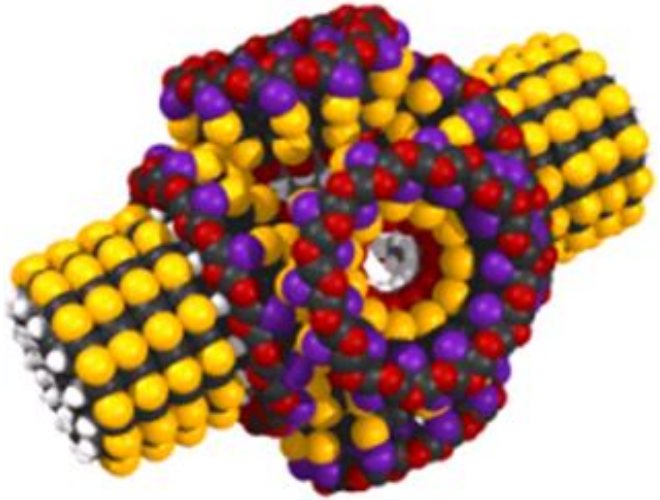
C60 Buckyballs (Fullerene)

http://en.wikipedia.org/wiki/Fullerene



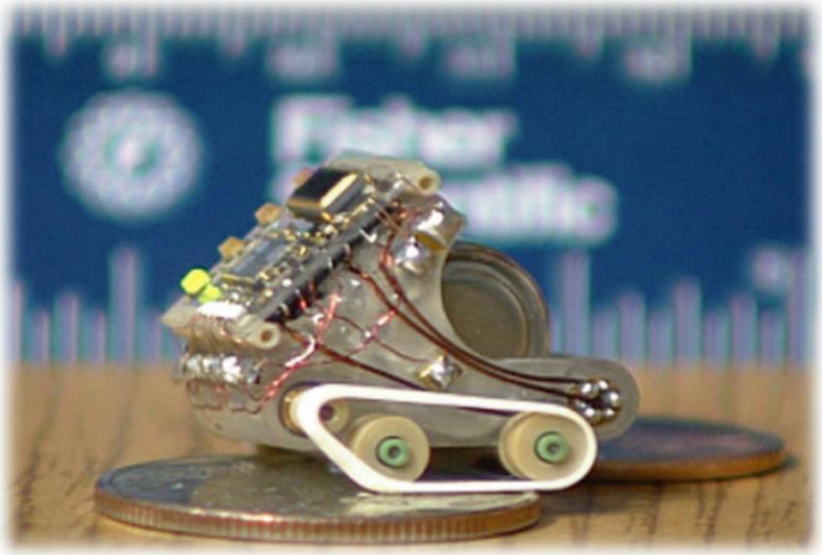
Carbon nanotubes

http://en.wikipedia.org/wiki/Fullerene



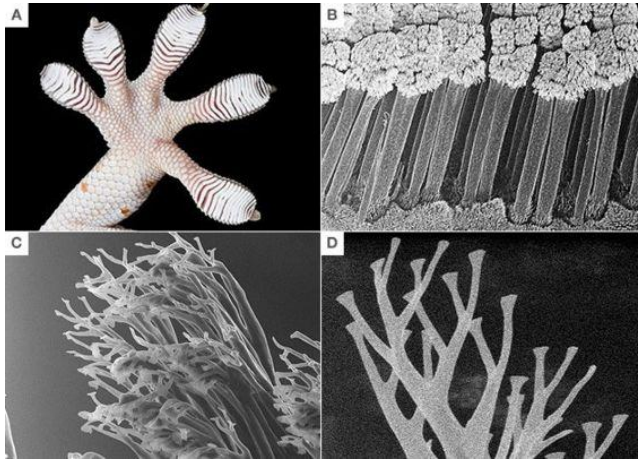
Eric Drexler Molecular machines

Micro/nano/pico/femto scale

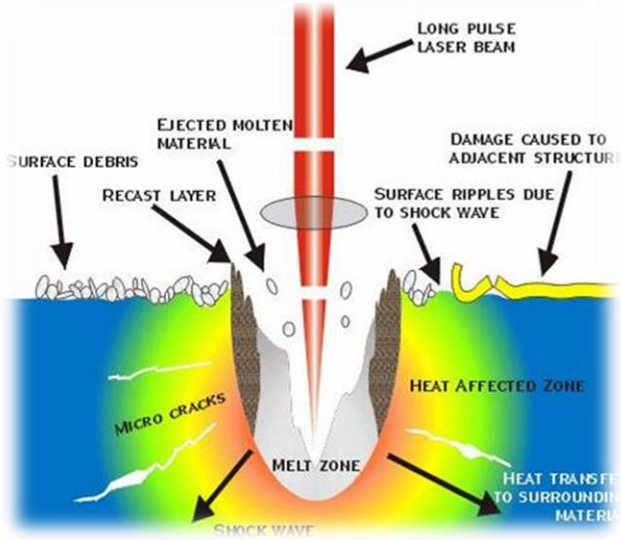


Sandia National Lab

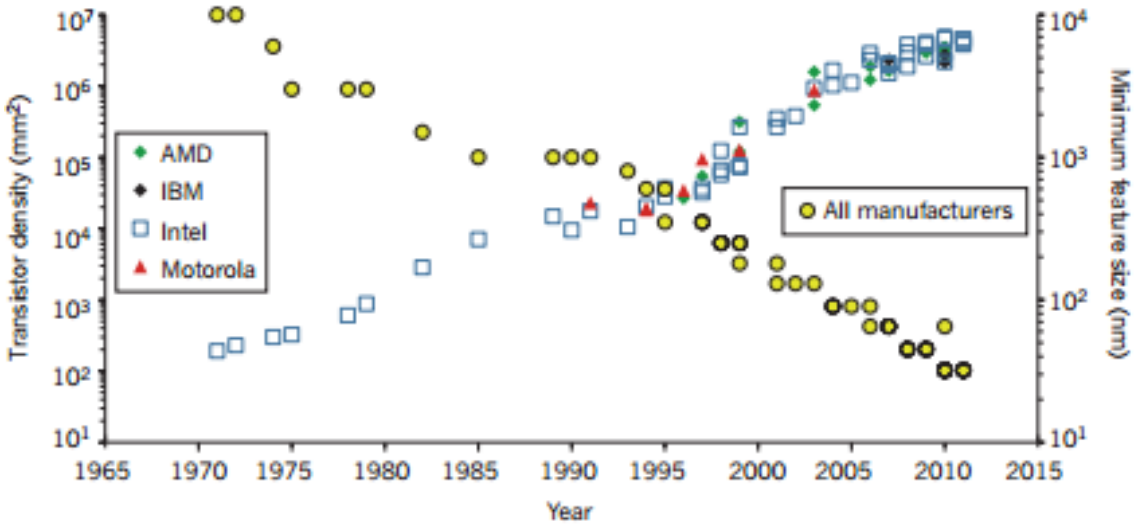
Harvard U.



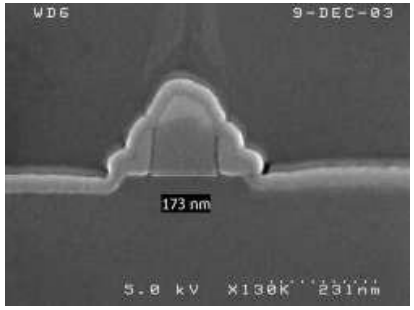
Stanford U.



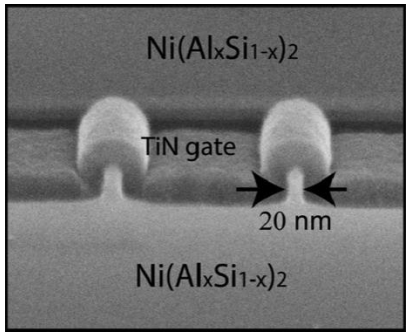
Moore's Law



The first transistor, AD 1947 [Wikipedia]



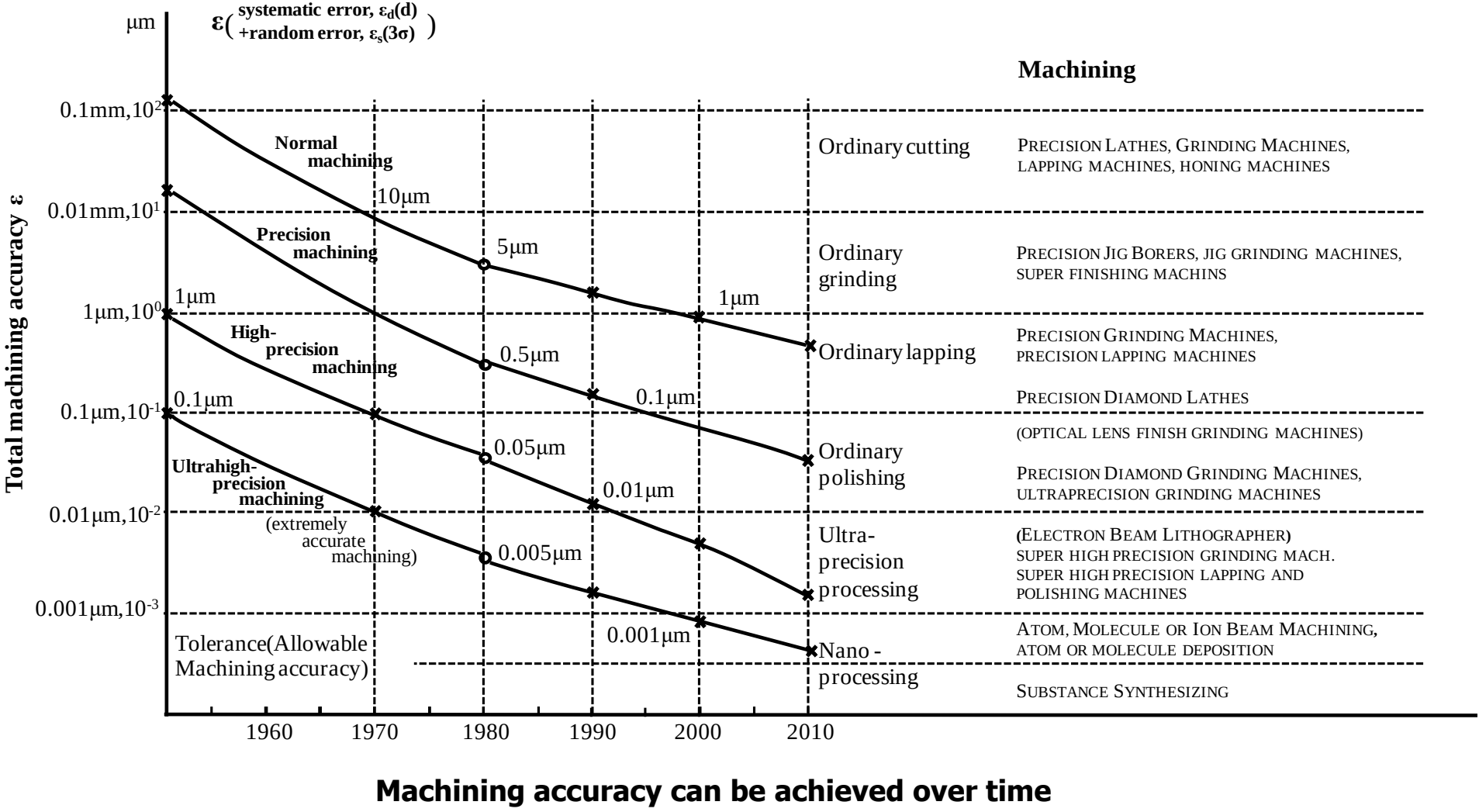
Gate of MOS transistor AD 21C, [http://www.muanalysis.com/]



Transistor with 20 nm Gate width [2]

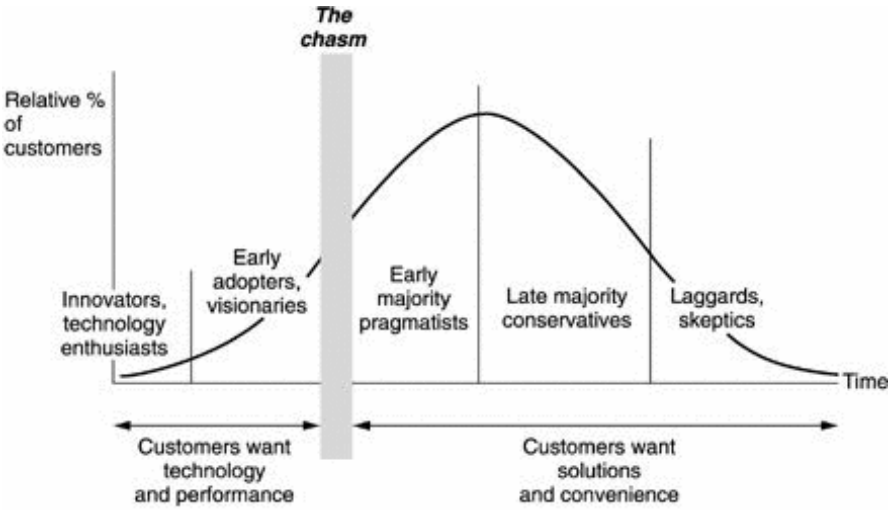
[1] Ferain, Isabelle, Cynthia A. Colinge, and Jean-Pierre Colinge. "Multigate transistors as the future of classical metal-oxide-semiconductor field-effect transistors." *Nature* 479.7373 (2011): 310-316.
[2] L. Knoll, Q.T. Zhao, A. Nichau, S. Richter, G.V. Luong, S. Trellenkamp, A. Schäfer, L. Selmi, K. K. Bourdelle, S. Mantl, "Demonstration of Improved Transient Response of Inverters with Steep Slope Strained Si NW TFETs by Reduction of TAT with Pulsed I-V and NW Scaling", Proc. of IEEE IEDM 2013.

Machining Accuracy

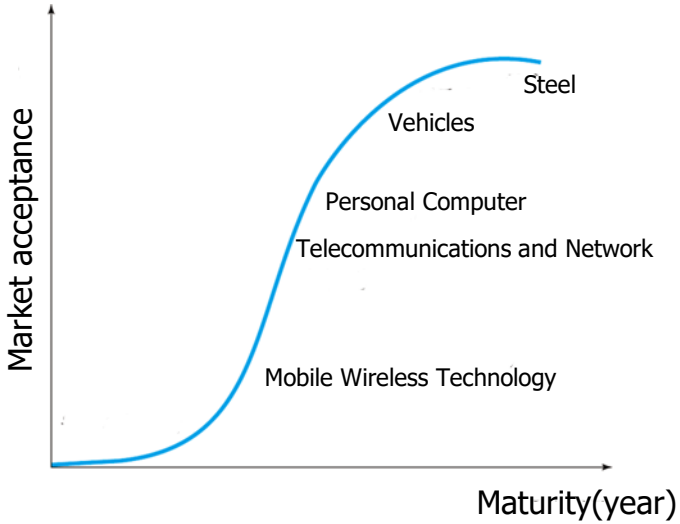


Machining accuracy can be achieved over time

Growth of technology

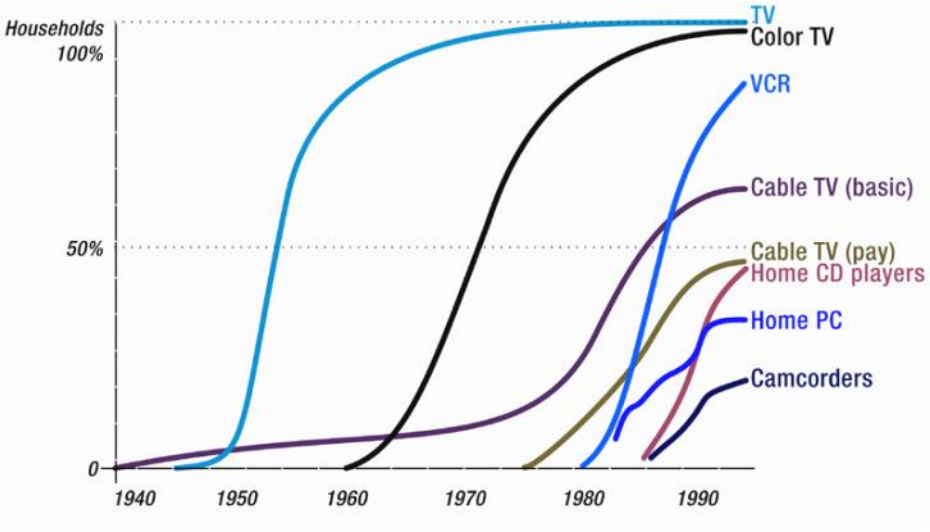


Geoffrey A. Moore, Crossing the Chasm, Marketing and Selling High-Tech Products to Mainstream Customer, HarperCollins Publishers, New York, 1999



Graph of market acceptance

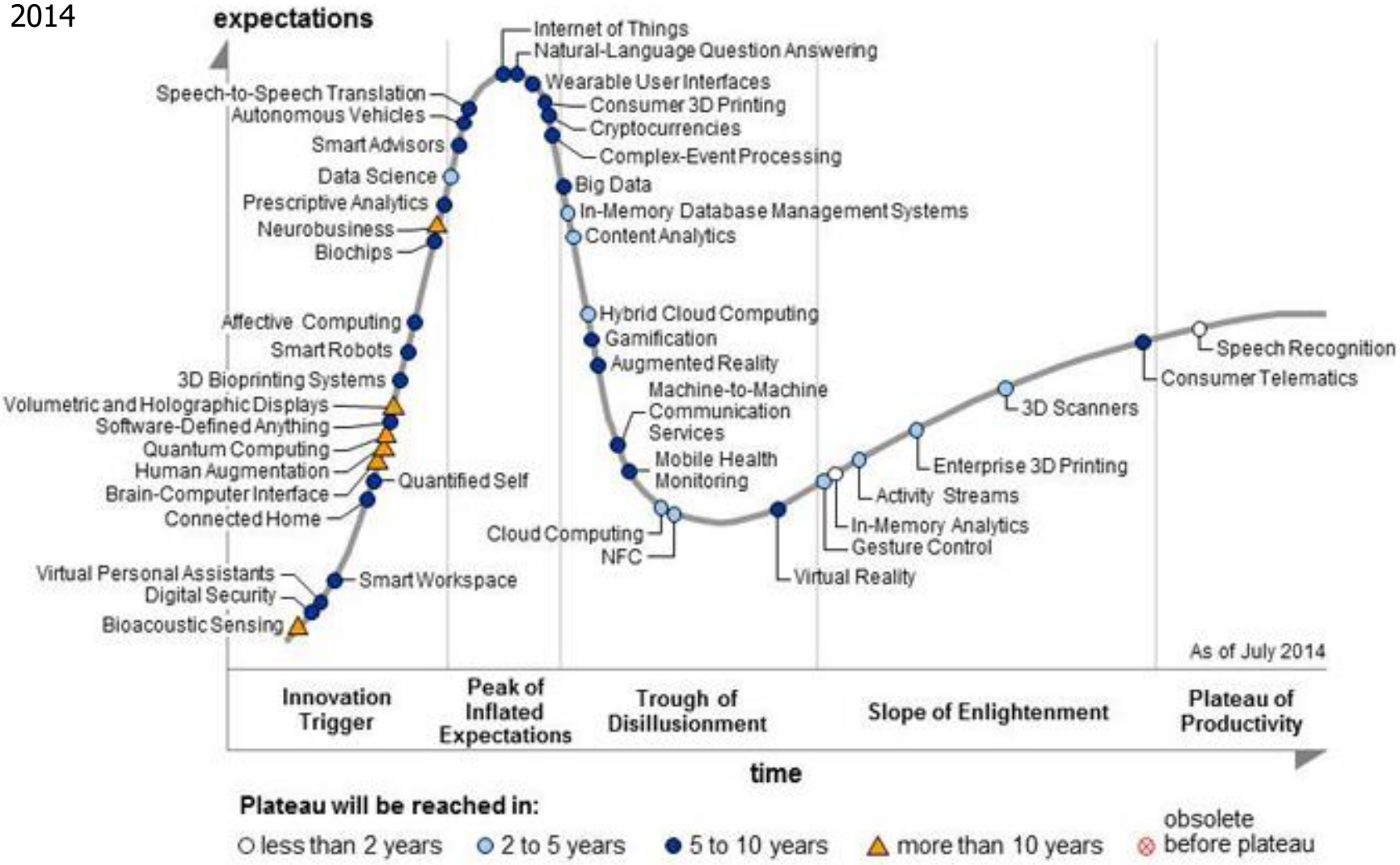
Fig. 2.2 on page 36 (21st Century Manufacturing)



Hype Cycle for Emerging Technologies, 2014 ~ 2017

http://www.gartner.com

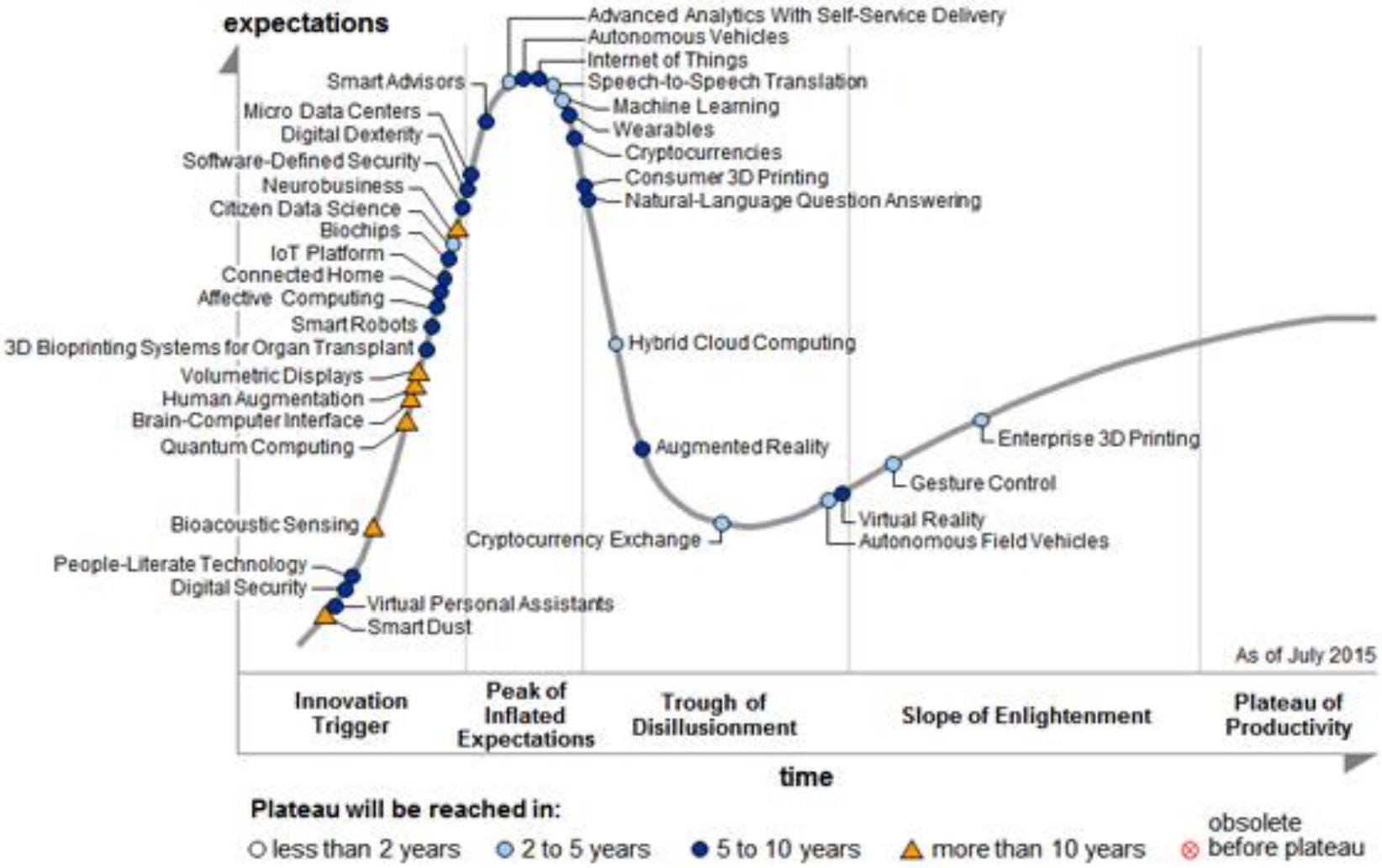
2014



Hype Cycle for Emerging Technologies, 2014 ~ 2017

http://www.gartner.com

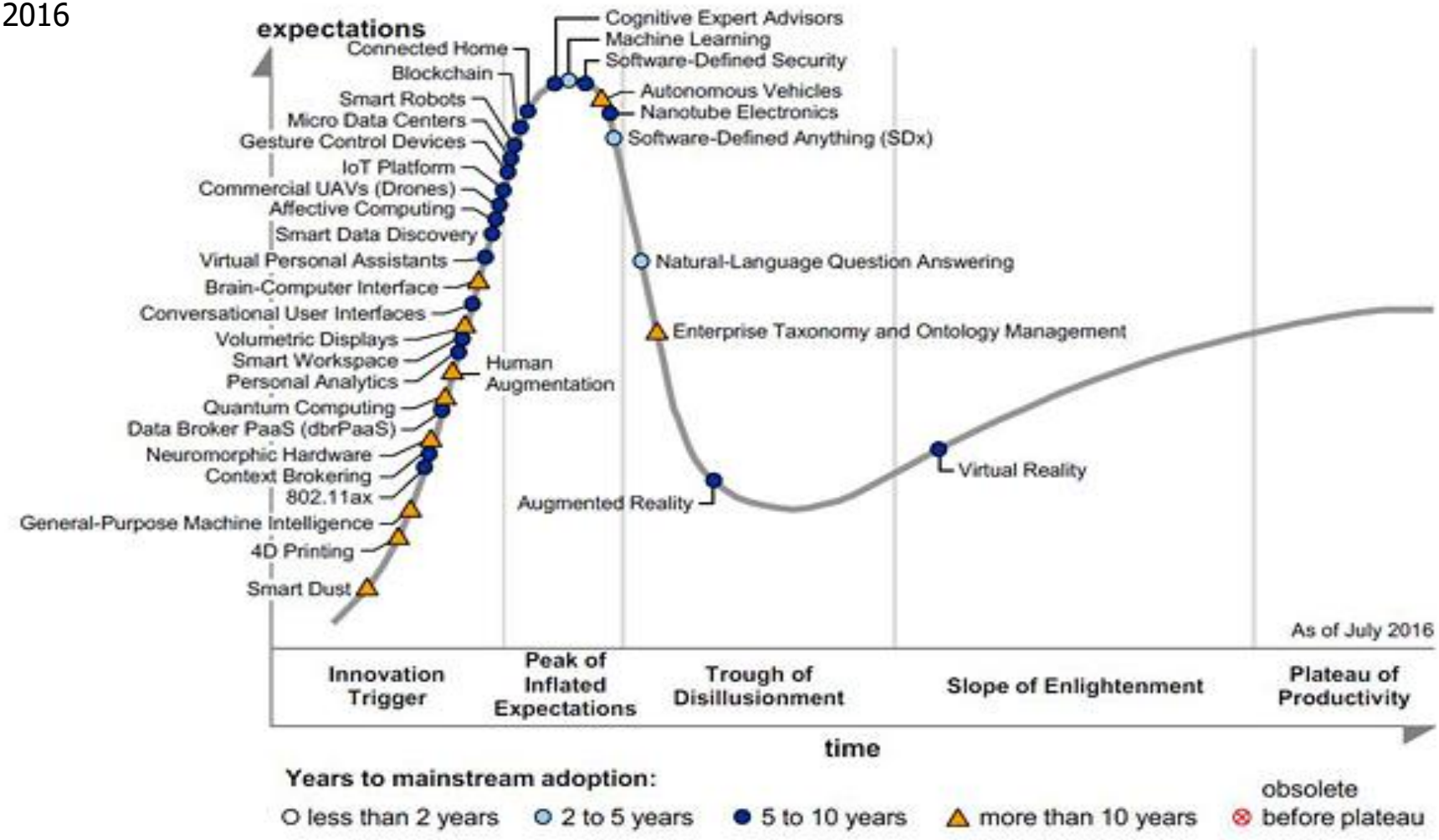
2015



Hype Cycle for Emerging Technologies, 2014 ~ 2017

http://www.gartner.com

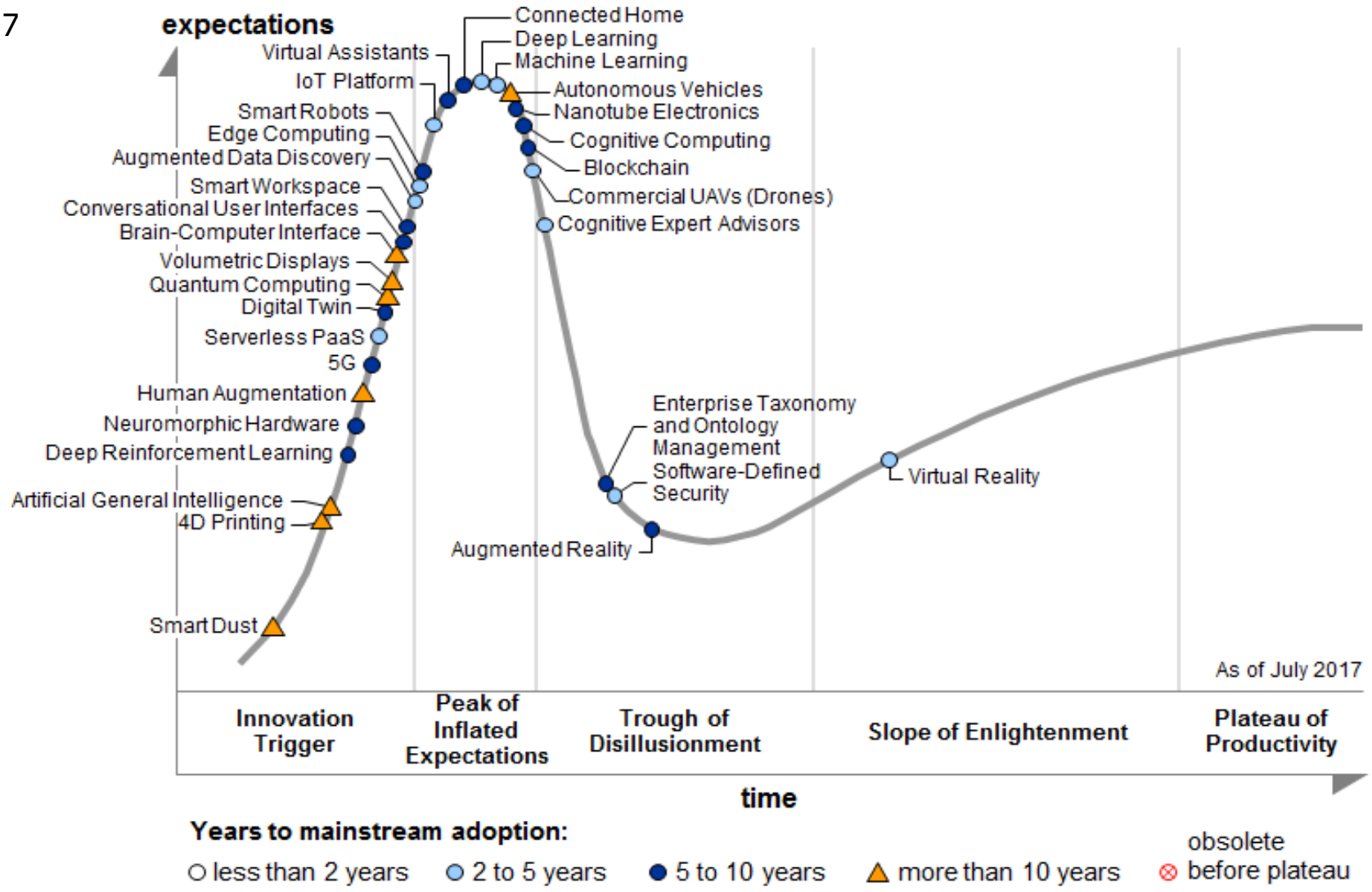
2016



Hype Cycle for Emerging Technologies, 2014 ~ 2017

http://www.gartner.com

2017



Situation in USA

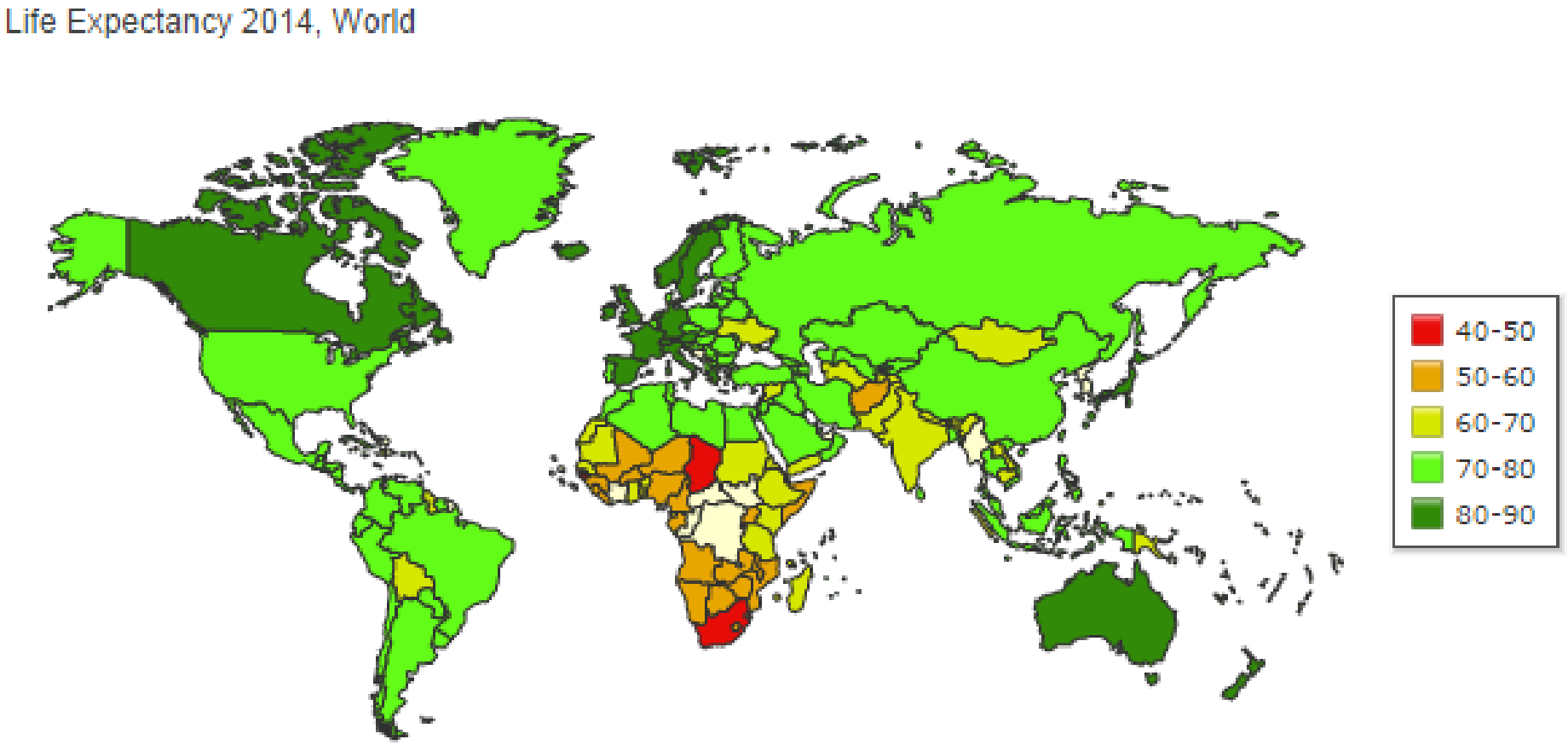
- **Q: How many Levi's jeans factories are in USA?**
  - 1980 → 60 factories
  - 2004 → ??
  - Sewing machine operator's minimum salaries
    - US 893
    - Honduras 139
    - Guandong 65
    - Bangladesh 19

History of life span

Queen Elizabeth 2nd, UK

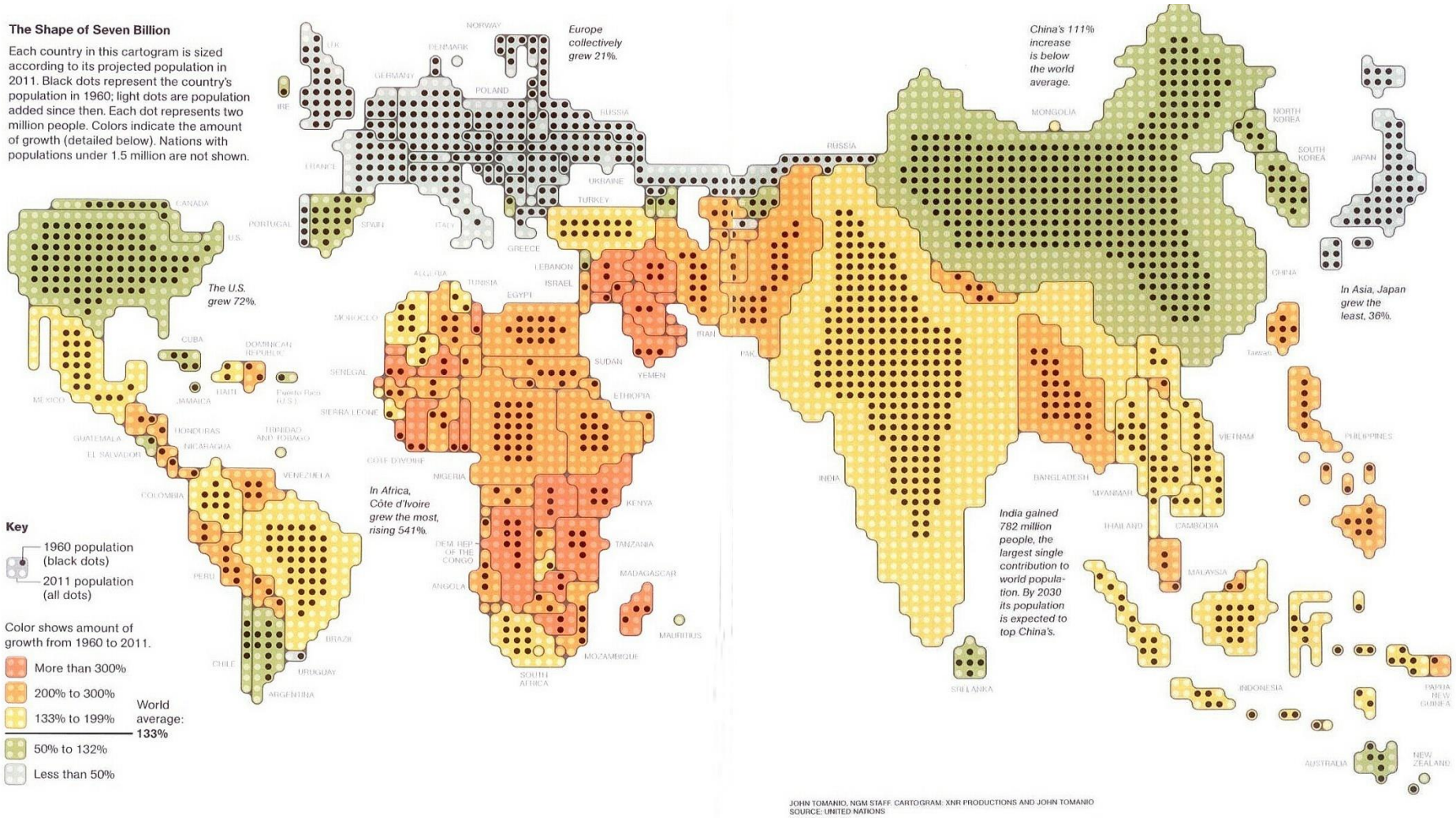
Ref: Old testament

Life expectancy at birth, 2010



Source: The word bank, 2014.

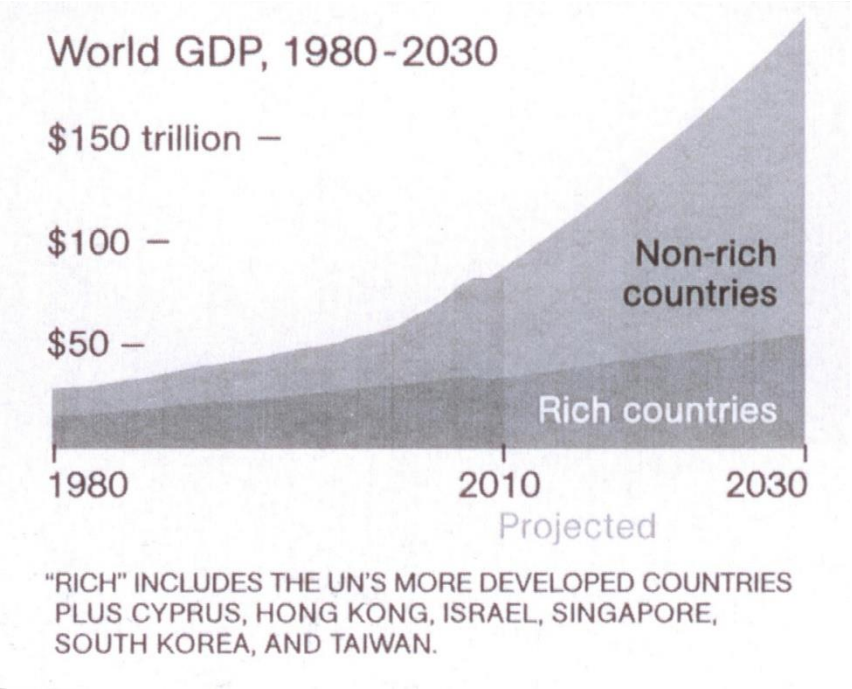
POPULATION

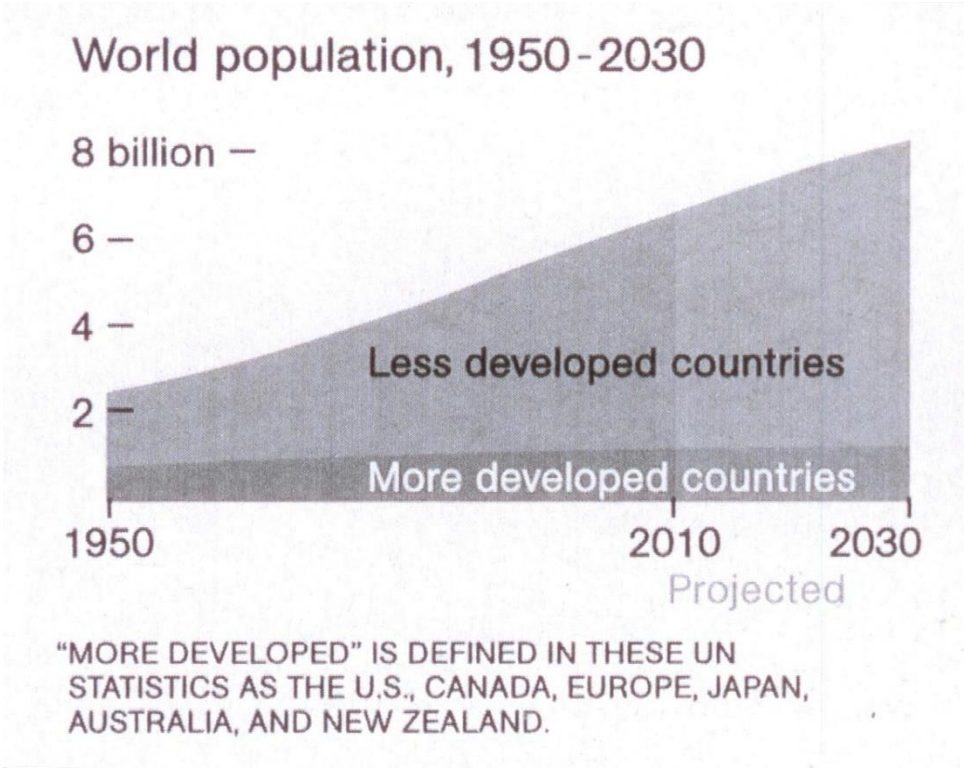


The less developed world will account for more than 95% of future population growth.

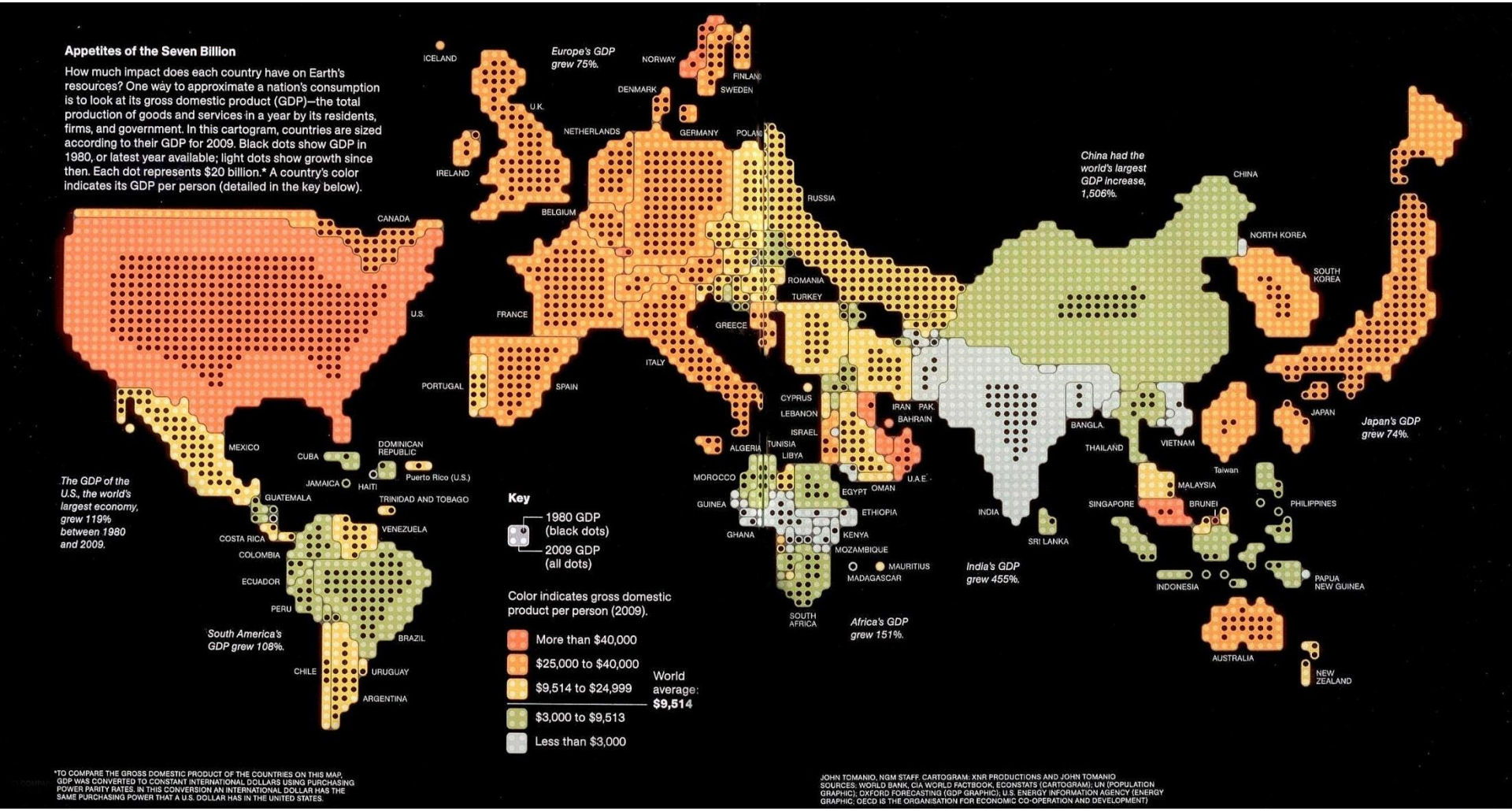
National Geographic, January 2011

World Population, GDP





CONSUMPTION



Wealthy nations use the most resources now, but emerging economies are catching up fast.

National Geographic, January 2011

Engineering Solutions: Base of the Pyramid

- The base of the economic pyramid has nearly 4 billion people (less than $4 per day)
- More than 1 billion do not have safe, dependable drinking water
- 1.2 billion lack adequate housing
- 2.4 billion live without tolerable sanitation

The World Economic Pyramid

Annual Per Capita Income*	Tiers	Population in Millions
More than $20,000	1	75-100
$1,500-$20,000	2 & 3	1,500-1,750
Less than $1,500	4	4,000

*Based on purchasing power parity in U.S.$ Source: U.N. World Development Reports

Engineering for Change

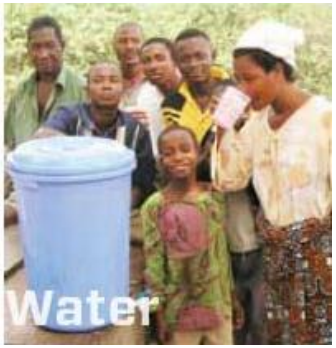
Designs must be simple and robust, capable of lasting years with minimal maintenance and also mesh with the culture and routines of the communities that will use them.

http://memagazine.asme.org/Articles/2011/March/Change.cfm

Possible areas for the term projects (1)

- **Appropriate Technology**

Water	Energy	Health



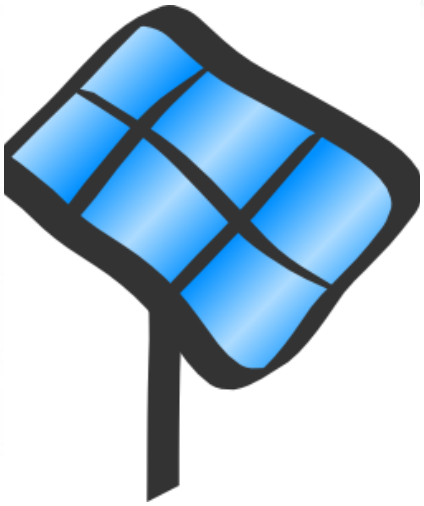
Structures	Agriculture	Sanitation	Info System

https://www.engineeringforchange.org/home

Possible areas for the term projects

- **Appropriate Technology**
  - **Solar Heater/Cooler/Energy**
    - Solar energy can be used to heat our homes, heat water, cook our food, and power our lights
    - Help you learn about solar energy and how it works.
  - **Micro Irrigation/pump**
    - Micro irrigation or low pressure has long been cons the future

Sugarcane Charcoal



http://d-lab.mit.edu/news/general/big-ideas-littte-packages

Possible areas for the term projects

- **Sustainable Design**
  - Columbia University's student developed a Listeroid diesel engine that runs on local vegetable oils used to mill grain and generate electricity.

  - Pennsylvania State University is developing low-cost medical instruments from plastic pipe, cardboard, and Velcro which send medical data by phone from rural clinics to city doctors who suggest treatment.

  - Princeton aerospace engineers designed solar powered refrigerators, so camels could carry chilled vaccines to clinics in Kenya, Nigeria, and Ethiopia.

Summary of Issues

- **Faster life cycle of product development**
- **More competition**
  - Global & local
  - Cost & quality
- **More people and longer life**
- **Problems in energy, environment, and climate**

Bill & Melinda Gates Foundation

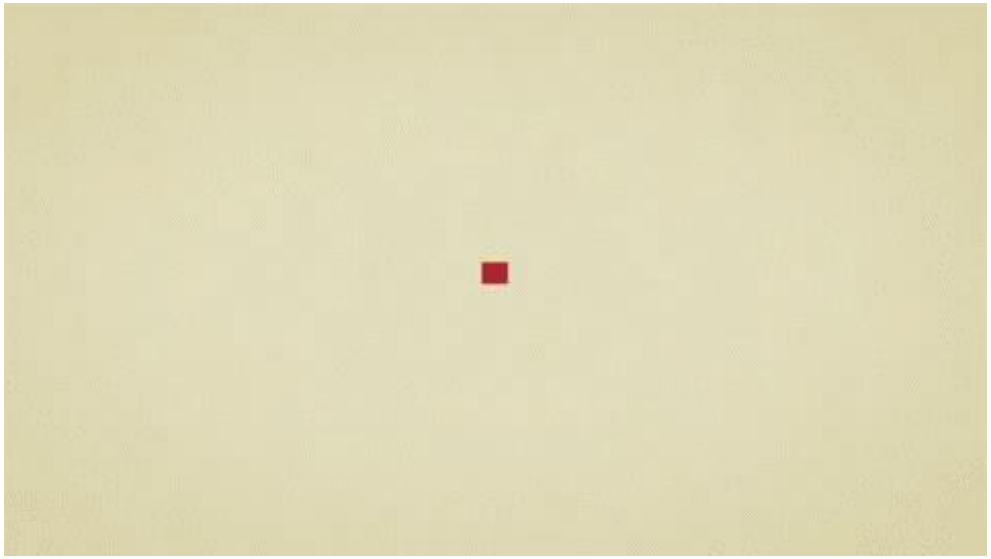
- **Reinvent the Toilet Challenge**
  - Support upstream research and development of a toilet
  - Not rely on water to flush waste or a septic system to process and store waste
  - A sanitation business that can be easily adopted by local entrepreneurs living in poor urban settings
  - First prize: $100,000, Second prize: $60,000, Third prize: $40,000

- **Gates Vaccine Innovation Award**
  - An annual award to the person or team that had made the most innovative contribution to Decade of Vaccines
  - Open to any individual or team
  - Total prize: $250,000

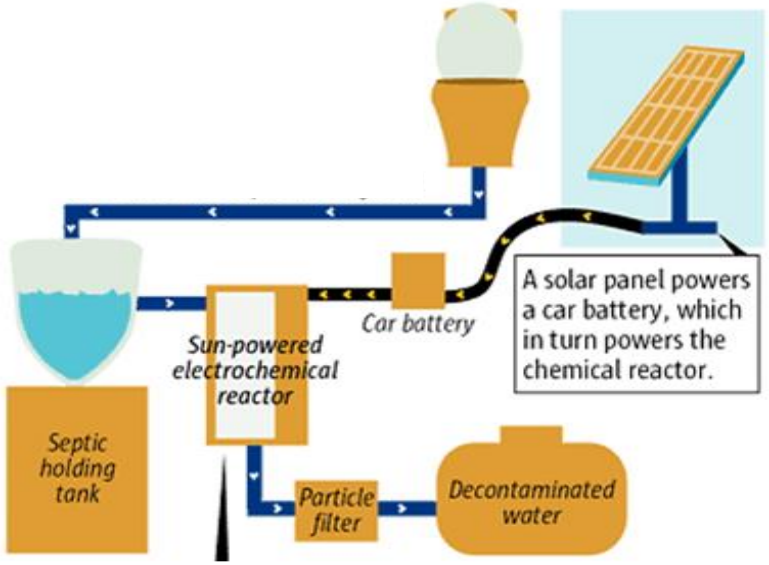
- **The College Knowledge Challenge**
  - To develop innovative apps on Facebook that will help students apply to attend and stay in college
  - Successful applicants will be granted $50,000 - $100,000

Reinvent the Toilet Challenge (1)

- Hygienic and sustainable for the world's poorest populations
- An operational cost of $0.05 per user, per day
- Not discharge pollutants, but instead generates energy and recovers salt, water and other nutrients
- Designed for use in a single family home
- The second Reinvent the Toilet Fair was held in New Delhi, India



The Reinvent the toilet challenge: India



Caltech's solar-powered toilet
(First prize in the toilet challenge 2012)

Reinvent the Toilet Challenge - Caltech

Reinvent the Toilet Challenge (2)

- The second Reinvent the Toilet Fair was held in New Delhi, India,2014

Gates Vaccine Innovation Award

- To protect children in the poorest parts of the world
- Innovation systems, processes, tools, and technologies leading to better immunization
- Key issues on the award
  - What is the innovation?
  - Why is this innovation important?
  - Who benefited from this innovation?
- Margarida Matsinhe (2013 winner)
  - A Mozambique based field officer for VillageReach, a social enterprise that works to increase access to healthcare for underserved communities
  - Trained in public health
  - Has helped increase access to vaccines for thousands of children
  - New approaches to improve the logistics of vaccine delivery

As a result of Ms. Matshnhe and VillageReach's work:
1.Decreasing vaccine stockouts from 80% to 1% in rural area of Mozambique
2.The amount of time the cold chain is working increased from 40% to 96%
3.The percentage of children receiving basic vaccines increased from 69% to 95%

Margarida Matsinhe
(Winner of 2013 gates vaccine award)

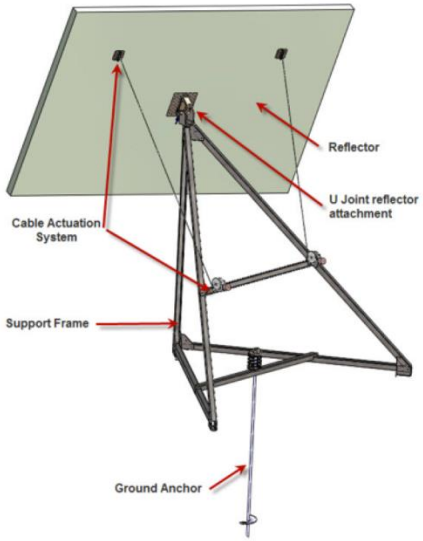
http://www.gatesfoundation.org/what-we-do/global-development/vaccine-delivery

Google Project

- **Google PowerMeter**
  - Free energy monitoring tool to raise awareness about the importance of energy.
  - Visualizations of energy usage, the ability share information with others, and personalized recommendations to save energy
- **RechargeIT**
  - System to demonstrate performance of electric vehicle (EV)
- **Earth Engine**
  - A planetary-scale platform for environmental data & analysis
- **RE<C (Renewable Energy Cheaper than Coal)**
  - Concentrating solar power (CSP) plants
- **Crisis Response**
  - Making critical information more accessible in times of disaster
- **Google Flu & Dengue Trend**
  - By using search term indicating of flu activity, aggregate data and estimate flu activity

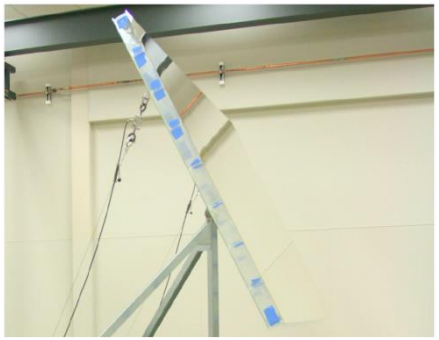
Google Project – RE<C

- **RE<C (Renewable Energy Cheaper than Coal)**
  - Concentrating solar power (CSP) plants
  - Smaller gas turbine (Brayton) engine
  - Cost reduction on Heliostats (mirror)



Prototype heliostat design

Power tower example



Glass mirror module

http://www.google.org/rec.html

Google Project – RE<C

Support on the project

- **Available hardware**
  - IDIM Lab. (room 1255 building 301)
    - 3D Printer, Humidity Chamber, Tensile machine, Micro milling, micro drilling, abrasive cutting, CNC, and injection molding, etc.
  - Out-sourcing
    - Laser cutting
    - 3D Printer
    - Etc.

Hardware support (1)

- **Manufacturing device**

Small sized 3D printer

Precise 3D printer

Multi-material 3D printer

Humidity chamber

Furnace

Drill

Band Saw

Lathe

Hardware support (2)

- **Usability evaluation tool**

High speed video camera

Surface roughness profiler

Abrasion test machine (Instron)

Motion Capture (Vicon Bonita Camera)

thermo-graphic camera

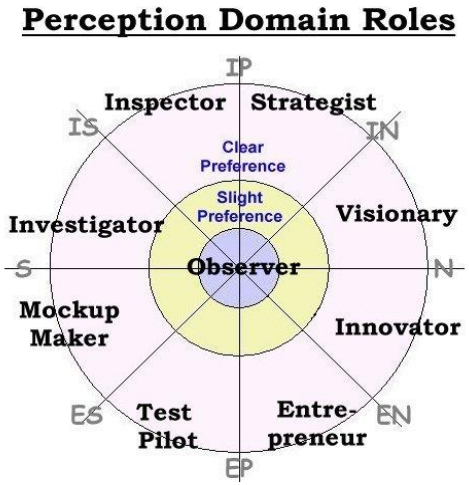
Long WD optical microscope

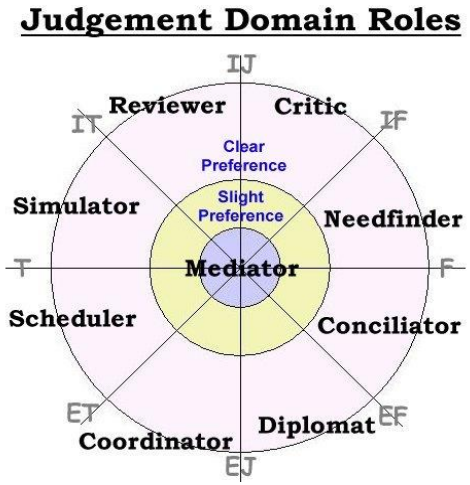
Assignment (1)

- **Knowing yourself**
  - Use the website and submit your personality result page
  - Due: **~~September 12 Tuesday 15:30~~**,
    upload to the etl.snu.ac.kr

http://www.humanmetrics.com/cgi-win/JTypes1.htm
Team Technology (Business Resources)

http://www.teamtechnology.co.uk/mmdi/questionnaire/





Assignment (2)

- **Make a team for class project**

1. Send your 1) Team members, 2) Project topic to TA through email.

   1) Organize a team with 3 - 4 people.

   2) Choose a project topic from below:

   (1) Appropriate Technology (AT)

   (2) Water Delivery Project in Tanzania

   (3) Agricultural Problems in Tanzania

   (4) Vaccine Delivery System

   (5) etc.(write your specific topic)

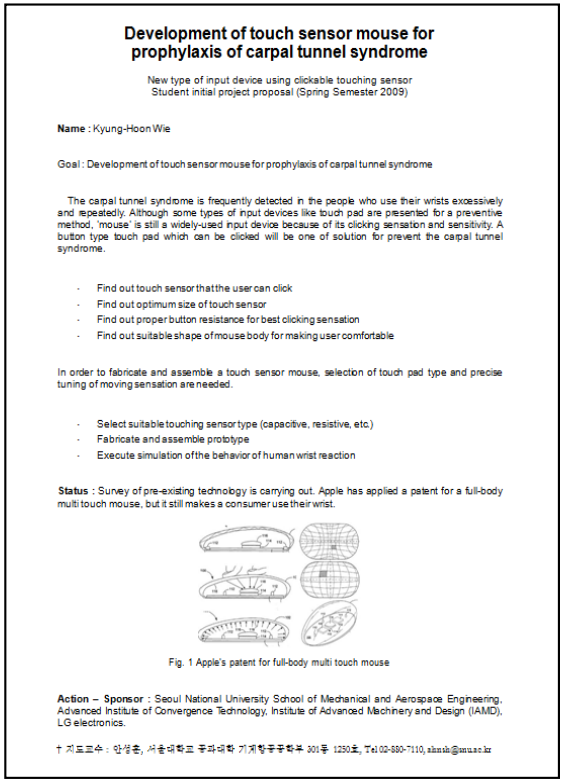
   3) At least one **Korean student has to join in each team.**

Due date: September 14 Thursday, 15:00

- If you cannot form a team, please let TA know. TA will arrange members for you.

Assignment (3)

- **Come up with an idea of your final project**
  - "Student proposal form" is available from etl.snu.ac.kr
  - Write a student proposal form per each team, not individual
  - Due: **September 22 (Friday) 23:59** upload at the ETL (Team leader only)



Development of touch sensor mouse for prophylaxis of carpal tunnel syndrome

New type of input device using clickable touching sensor
Student initial project proposal (Spring Semester 2009)

Name : Kyung-Hoon Wie

Goal : Development of touch sensor mouse for prophylaxis of carpal tunnel syndrome

The carpal tunnel syndrome is frequently detected in the people who use their wrists excessively and repeatedly. Although some types of input devices like touch pad are presented for a preventive method, 'mouse' is still a widely-used input device because of its clicking sensation and sensitivity. A button type touch pad which can be clicked will be one of solution for prevent the carpal tunnel syndrome.

- Find out touch sensor that the user can click
- Find out optimum size of touch sensor
- Find out proper button resistance for best clicking sensation
- Find out suitable shape of mouse body for making user comfortable

In order to fabricate and assemble a touch sensor mouse, selection of touch pad type and precise tuning of moving sensation are needed.

- Select suitable touching sensor type (capacitive, resistive, etc.)
- Fabricate and assemble prototype
- Execute simulation of the behavior of human wrist reaction

Status : Survey of pre-existing technology is carrying out. Apple has applied a patent for a full-body multi touch mouse, but it still makes a consumer use their wrist.

Fig. 1 Apple's patent for full-body multi touch mouse

Action – Sponsor : Seoul National University School of Mechanical and Aerospace Engineering, Advanced Institute of Convergence Technology, Institute of Advanced Machinery and Design (IAMD), LG electronics.

† 지도교수 : 안성훈, 서울대학교 공과대학 기계항공공학부 301동 1250호, Tel 02-880-7110, shinsh@snu.ac.kr

Notice

- **Submit agreement forms at the end of class**
  1) Agreement to Collect and Use Personal Information (for lecture)
  2) Agreement Form

- **Upload your Profile picture at ETL**
  1) My courses → My profile setting → User picture
  2) We will put your picture at the attendance book