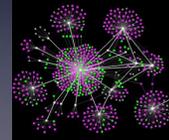


Mapping the Landscape of Bioscience Innovation

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AURP 2010 International Conference
 Minneapolis, Minnesota
 September 17, 2010

Clusters -- linking key elements of bioscience innovation



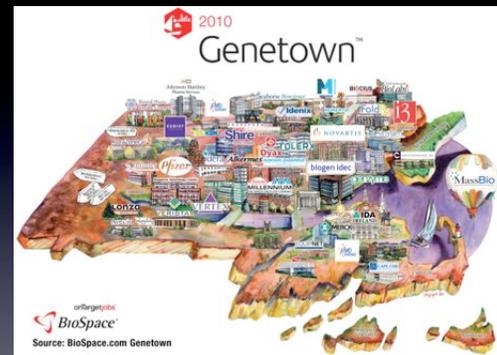
Clusters

When an industry has thus chosen a locality for itself, it is likely to stay there long; so great are the advantages which people following the same skilled trade get from near neighborhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air....

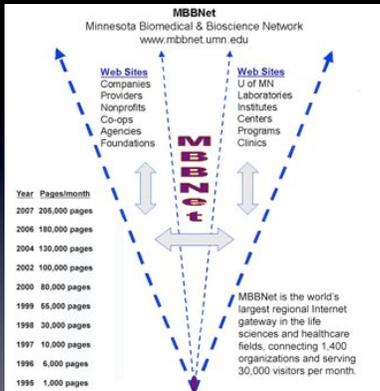
-- Alfred Marshall
Principles of Economics
 1890

The process of industry evolution often breeds new competitive industries and hence builds or extends a cluster. Thus portions of a nation's economy that extends beyond individual industries and is a powerful force for economic development.

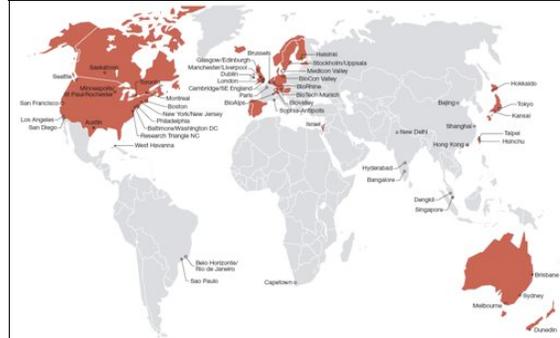
-- Michael Porter
The Competitive Advantage of Nations
 1990



"Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, and associated institutions in a particular field that are present in a nation or region." Institute for Strategy and Competitiveness, Harvard Business School

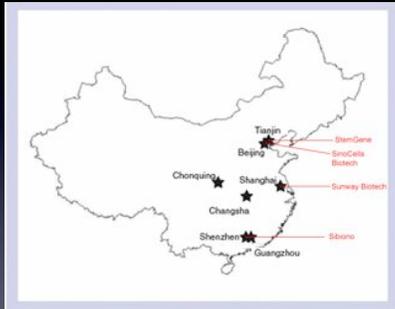


Global Bioscience Clusters



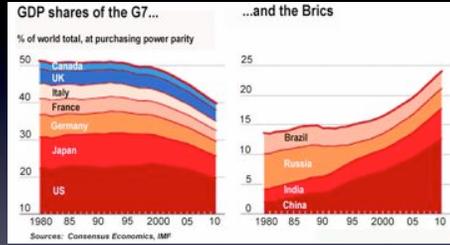
Map by William Hoffman from "More Than the Sum of Their Parts? Clustering is becoming more prevalent in the biosciences, despite concerns over the sustainability and economic effectiveness of science parks and hubs" by Andrea Rinaldi, EMBO reports, February 2005.

Centers of Regenerative Medicine in China



Map modified from Fig. 2 of "Cultivating regenerative medicine innovation in China," McMahon, Thorsteinsdóttir, Singer & Daar, *Regenerative Medicine* 5 (1), 2010.

Global Shares of GDP: G7 and the Brics



From Martin Wolf, *Financial Times*, Feb. 2, 2010. By 2030, the IMF forecasts that the Asian GDP will exceed that of the Group of Seven (G7) industrialized economies.

Emerging biotechnologies with revolutionary potential



Regenerative Medicine: Miromatrix Medical, Inc.



www.miromatrix.com

"The breadth and depth of the applications for the Miromatrix technology is staggering. It will enable the replacement of entire organs (e.g. heart, liver, kidney, pancreas) with non-transplantable organs harvested from either animals or donors, stripped of their cells and recellularized with either cells from the recipient or compatible cells. The potential market for the Miromatrix organ replacement technology is enormous..." - Miromatrix Medical, Inc.

Regenerative Medicine: Recreating the Lung



Orthotopic transplantation of a regenerated left lung construct. Harald C. Ott et al., "Regeneration and orthotopic transplantation of a bioartificial lung." *Nature Medicine*, July 13, 2010.

Regenerative Medicine: Recreating the Lung

L 19 orthotopic TX
Fluoroscopy

Fluoroscopy after orthotopic transplantation of a regenerated left lung construct. Harald C. Ott et al., "Regeneration and orthotopic transplantation of a bioartificial lung." *Nature Medicine*, July 13, 2010.

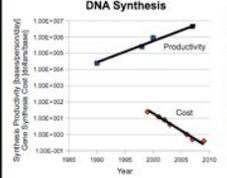
Regenerative Medicine: Recreating the Lung



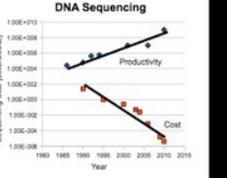
"Development of a Decellularized Lung Bioreactor System for Bioengineering the Lung: The Matrix Reloaded," Andrew Price et al. *Tissue Engineering*, May 21, 2010

Exponential Progress in Reading DNA and Writing DNA

DNA Synthesis



DNA Sequencing



Sources: Biodesic, www.synthesis.co

From Robert Carlson, Biodesic LLC. Presented at the President's Bioethics Commission meeting on Synthetic Biology, Washington, DC, July 6, 2010.

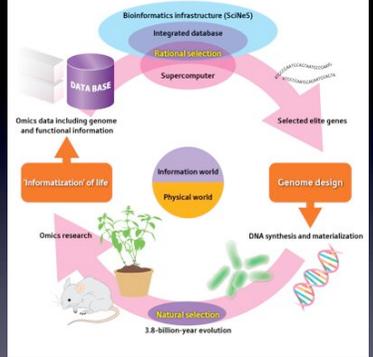
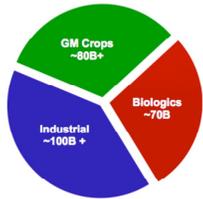


Figure 1. Omics-driven evolution expands the cycle of gene evolution to the information realm. From Tetsuro Toyoda, "Synthetic biology, creating biological resources from information resources," August 10, 2010.

"Genetically Modified Stuff" in the US Bioeconomy (2010 est.): >\$250B or Equivalent of ~2% of GDP

U.S. Biotech Revenues in \$ Billions



GM revenue growth: Crops 10%, Biologics 10%, Industrial 20%. (Sources: Nat Biotech, Forbes, FT, Bloomberg)

Just 1/6 of 1% of workforce in U.S. contributed >5% of GDP growth in the years 2000 to 2007. (Sources: BEA, Nat Biotech, Biodesic)

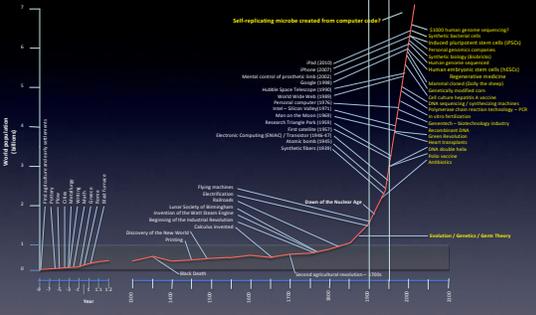
McKinsey and E&Y estimates for industrial apps range from \$70B to \$140B.

US DDC value added to GDP (2007): mining 2%, construction 4.1%, information and broadcasting 4.7%, all of manufacturing 11.7%, transportation and warehousing 2.9%, finance 20.7%, and all of government 12.6%.

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From Robert Carlson, Biodesic LLC. Presented at the President's Bioethics Commission meeting on Synthetic Biology, Washington, DC, July 8, 2010.

Innovation: The Multi-Millennial Journey



Modified from Fig. 1, "Catching up with the Economy," Robert W. Fogel, *American Economic Review*, March 1999. With the assistance of James Hudak.

James Madison on innovation

"And it is asked by what authority this bold and radical innovation was undertaken."

Commenting on the proposed structure of the national government in the *Federalist Papers* No. 39, Jan. 16, 1788