A close-up photograph of a person's hand wearing a white nitrile glove. The hand is holding a glass pipette, which is positioned over a green plant stem. The background is a blurred, light blue-grey color. The text is overlaid on the image.

The Ecosystem of the Biotech Industry in the United States

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November 2016

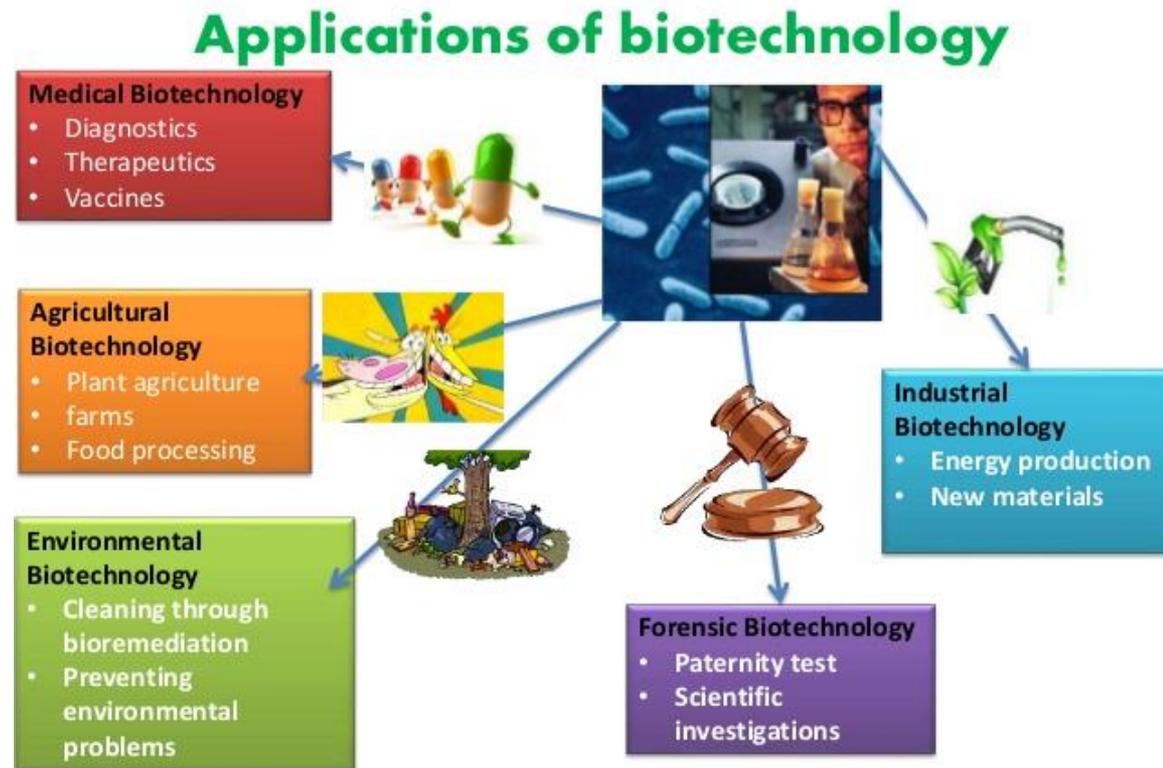
“Ecosystem”: In biology, an ecosystem is a



- community of living organisms in conjunction with the nonliving components of their environment, interacting as a system.
- Ecosystems are networks of interactions among organisms, and between organisms and their environment, influenced by internal and external factors that control the overall structure of the system.
- Ecosystems are dynamic entities, subject to periodic disturbances, always recovering from some past disturbance.
- ***This is a fitting metaphor for the biotech industry.***

Biotechnology: technology based on biology. Biotech harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet, providing breakthrough products and advances

- to combat debilitating and rare diseases,
- to reduce our environmental footprint,
- to feed the hungry,
- to use less and cleaner energy, and
- to have safer, cleaner and more efficient industrial manufacturing processes.



The bio-industrial ecosystem in the U.S.

- Whether taken as a whole or in its parts, the bio-industrial ecosystem in the United States is today healthy, prosperous and growing.
- American biotech industries and their related institutions provide numerous attractive opportunities for investment, research and development, commercial production, and general improvement of the quality of life around the globe.
- As of March 2016, trends in the U.S. indicate that “biological technologies are likely to generate an increasing share of both GDP and annual GDP growth.”
- Moreover, the U.S. “is the country with the largest biotech sector,” and biotech is making a “remarkable and accelerating transformation of the U.S. economy.”
- Biotech accounted for a conservatively estimated \$324 billion in revenues in 2014, more than 2% of GDP.
 - *Quotations and figures from Robert Carlson in Nature Biotechnology (34) 3, March 2016*

The bio-industrial ecosystem in the U.S., continued

- The basic components of the industry include
 - Universities (teaching, basic research, technology transfers to industry and the market);
 - R&D institutions (basic and applied research);
 - Manufacturers, distributors, retailers and consumers;
 - Government (federal, state and local levels—research institutes, regulators, legislatures).

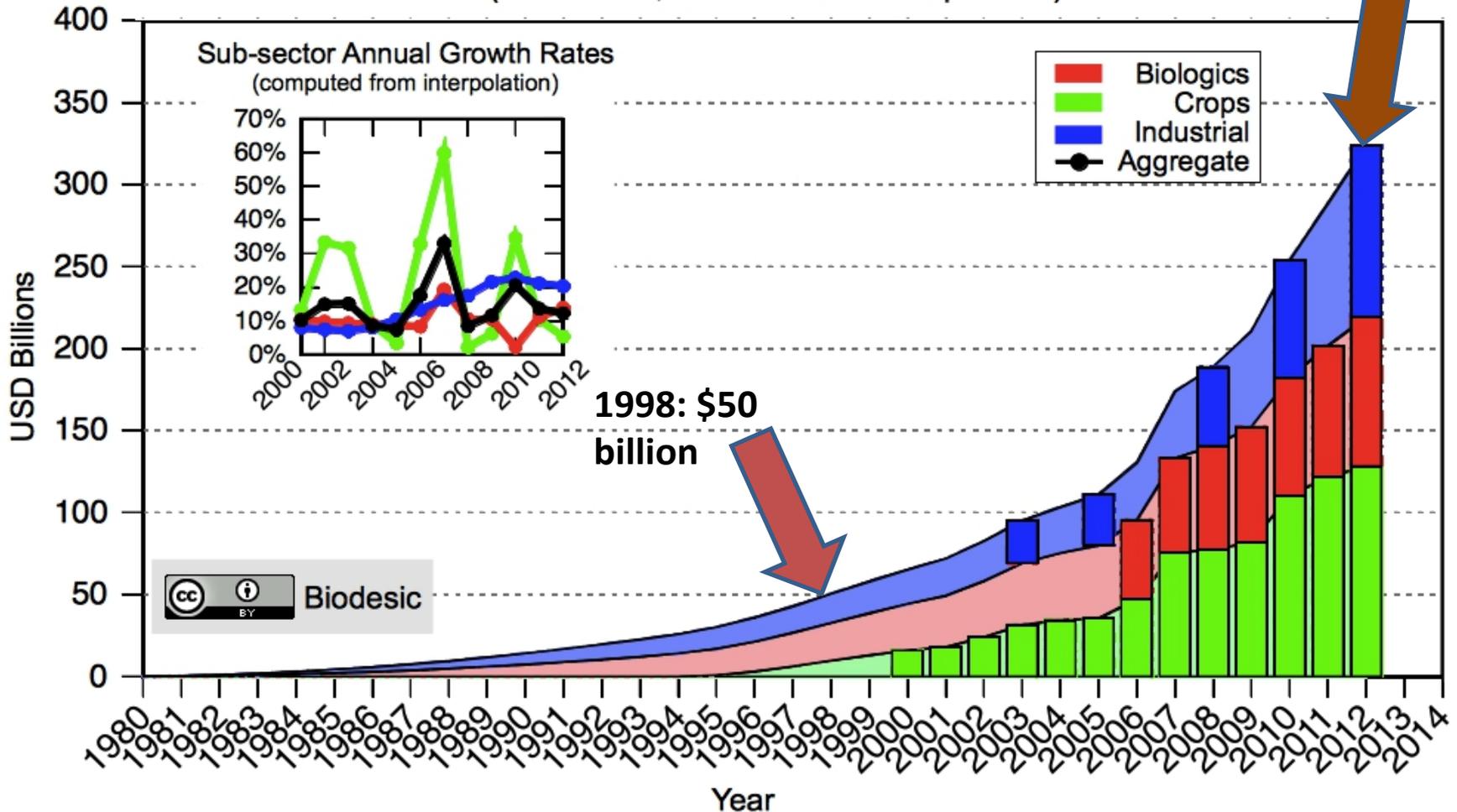
- Sectors within the industry include
 - Biologics (drugs)--\$91 billion in 2014;
 - Crops and seeds--\$128 billion in 2014;
 - Industrial products (biofuels, enzymes, biomaterials and biochemicals)--\$105 billion in 2014.



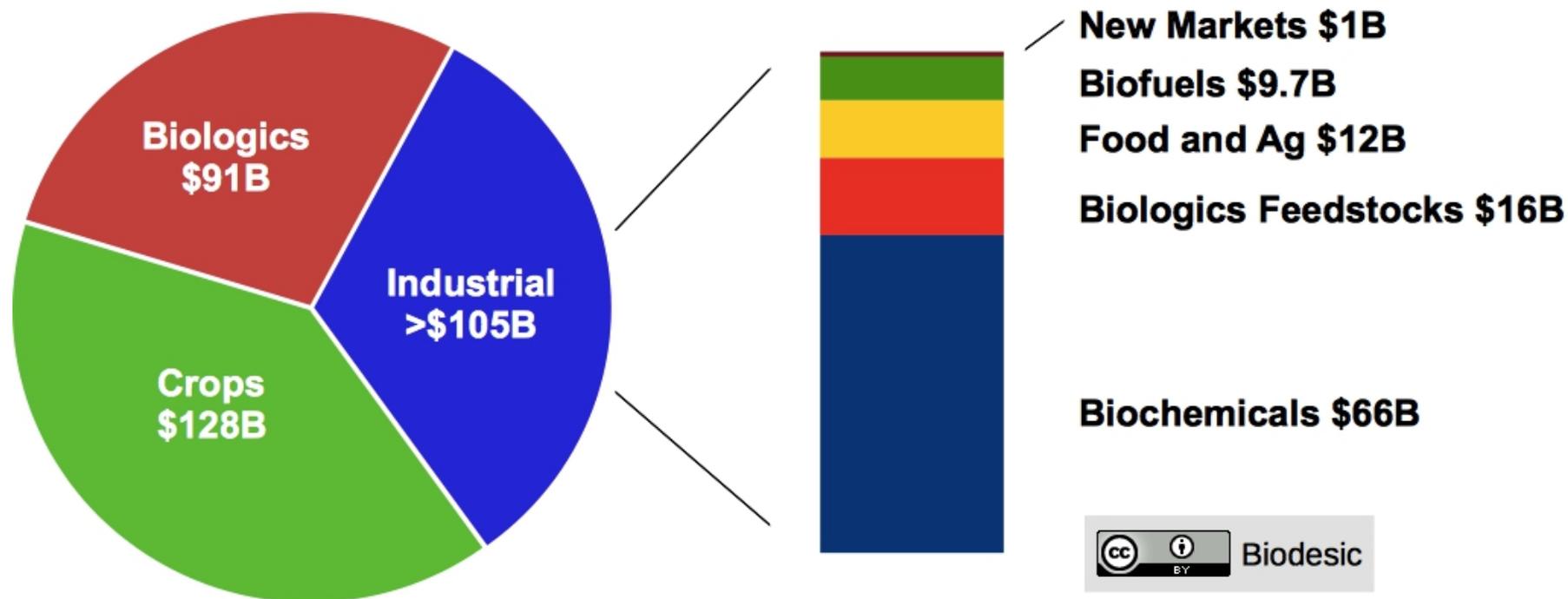
Recent Revenue Trends in U.S. Biotech

Estimated U.S. Biotech Revenues 1980-2012
(bars = data, shaded area = interpolation)

2012: \$324 billion



Components of 2012 U.S. Biotechnology Revenues



As published in R. Carlson, Nature Biotechnology, March 2016. Data and figures available at www.biodesic.com.

2012 Bioeconomy Components by Biodesic is licensed under a Creative Commons Attribution 4.0 International License.

Funding: principal sources of funding for biotech R&D, startups, manufacturing and distribution include:

- grants from federal, state and local governmental agencies,
- venture capitalists,
- “angel investors,”
- securities markets, etc.



In 2015, the National Institutes of Health alone provided a total of \$21.2 billion in research grants.

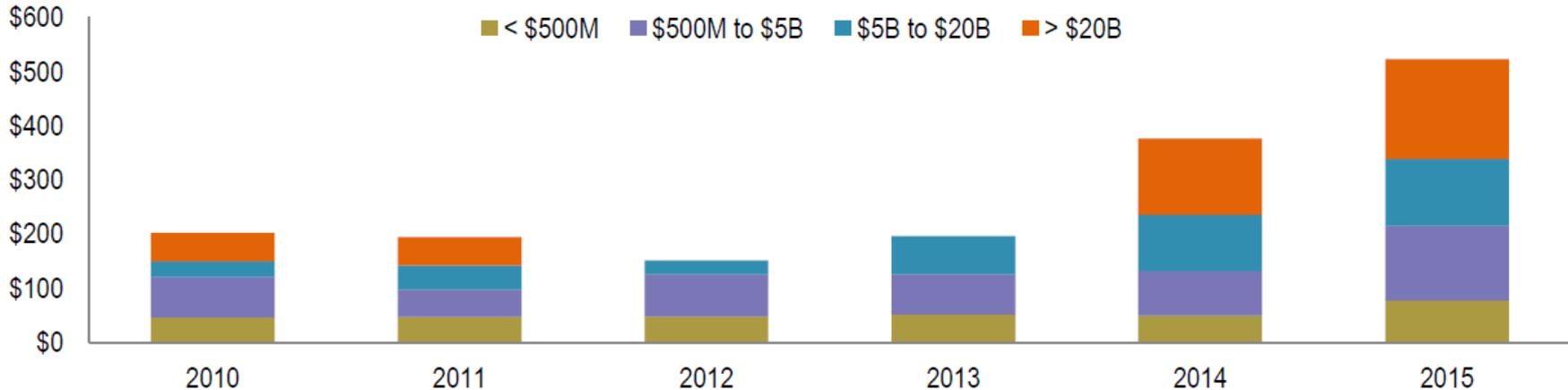


“In an industry...defined by innovation, **research remains a high-risk, high-expense proposition.** However, venture capital funding and industry investment has led to an uptick in small and medium-sized biopharmaceutical companies and presents a unique opportunity for larger players to engage in niche research and manufacturing.” (JLL)

Biotech Venture Capital Funding

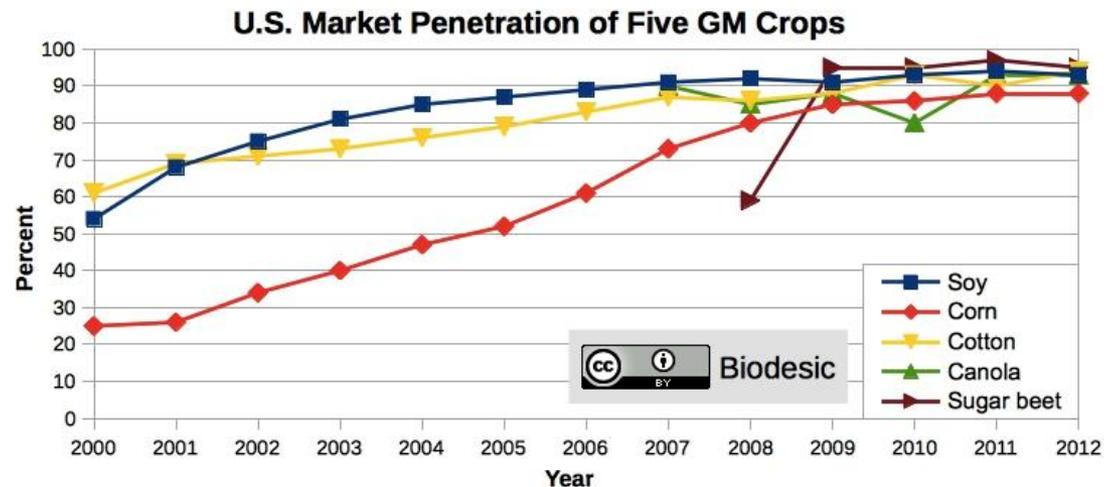
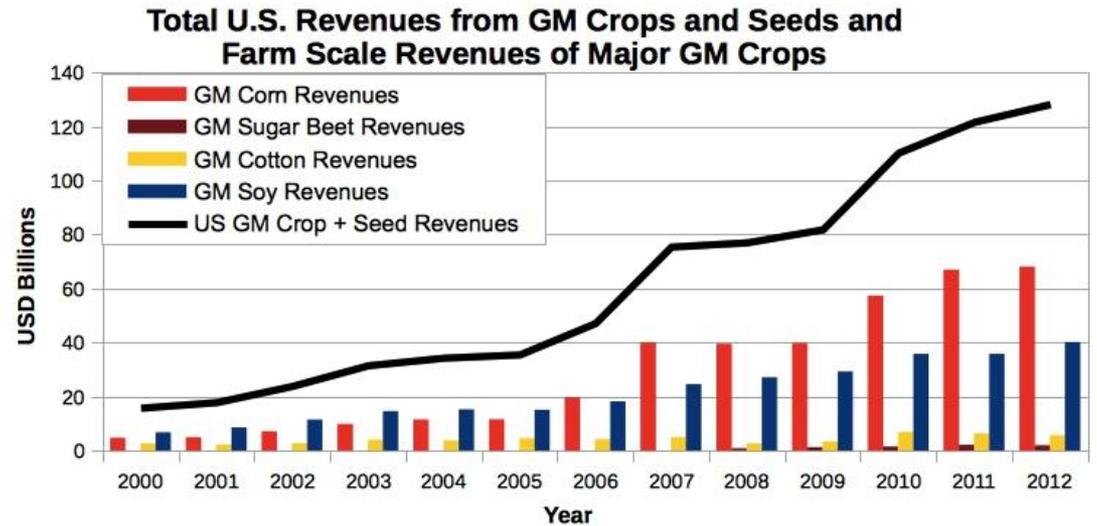
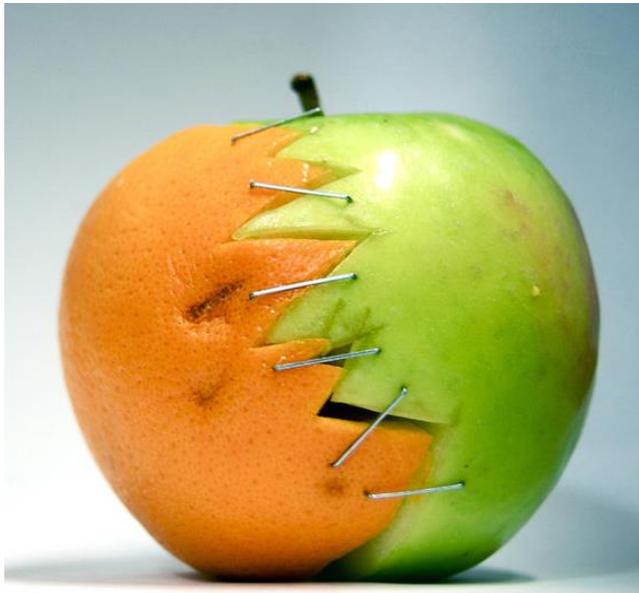


Total Biotech Healthcare M&A Deals



Source: Dealogic; Bain

Performance of the agricultural sector in the U.S., 2000 -2012



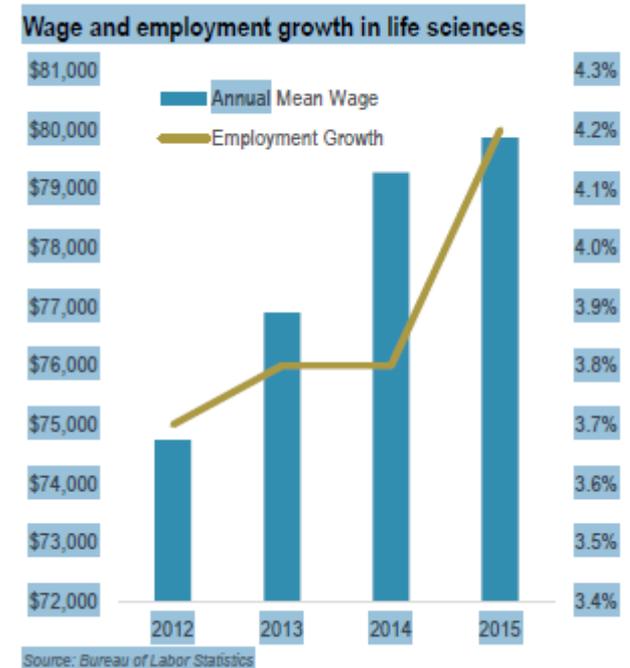
As published in R. Carlson, Nature Biotechnology, March 2016. Source data and figure available at www.biodesic.com.

Further components of the bio-industrial ecosystem

- **Real Estate:** at present (March 2016), vacancy rates for life-sciences properties are “astonishingly low” across the U.S., and rents continue to climb to historic highs.
 - This puts profitability pressures on the life-sciences companies, but provides fertile ground for real estate investment and construction.
 - “Life sciences properties offer investors the security of guaranteed cash flow from long-term leases by credit tenants in a sustainable and growing industry.”
(JLL)

- **Human Resources:**

- Annual biotech wages in the U.S. have grown 7.6% since 2011.
- Average salaries in the life sciences industry are nearly \$80,000.
- Continued upward growth in wages is anticipated into the foreseeable future.
- More than 810,000 people work in the U.S. biopharmaceutical industry alone (U.S. Census, 2012).



Understanding the meaning and impact of “biotechnology”

- Robert Carlson, PhD, a leading expert in biotechnologies and their role in the economy, paints a glowing picture of the industry in the U.S., as the previous graphs demonstrate.
- In a recent journal article, however, Carlson stresses that these figures represent “reasonable approximations of the contribution of biotech to GDP,” and that the whole field should be reformulated and evaluated in the context of a “biobased economy”:
 - “a unified picture of all the activity and jobs generated by the use and conversion of agricultural feedstocks to higher-value products; the use of microbes and enzymes as transformation agents or for process changes; and the production of bio-based products and biofuels.”
 - ***Without such reformulation, the existing economic statistics might represent an underestimation of the value of the industry of between 10 and 20 percent.***

And finally....



- **The importance of place:**

- Attracting, developing and retaining top talent is key to companies' growth.
- Proximity to institutions of higher education is crucial for life-sciences firms and their real estate decisions.
- Long-term trends indicate that companies seek locations and build their spaces with the intention of improving their employees' well being.
 - They select sites in locations believed to be conducive to well being in multiple attributes. (*Richard Florida*)
 - They provide abundant on-site amenities such as fitness centers and day-care centers.
 - "As one of the most innovative and challenging industries, it is clear the underlying value of human capital is driving the prioritization of capital across the globe." (*JLL*)

The national picture:

U.S. cluster rankings

Rank	Cluster	Weighted score	Rank	Cluster	Weighted score
1	Greater Boston	87.5	9	Westchester County, N.Y.	41.2
2	San Francisco Bay Area	75.2	10	New Jersey	40.8
3	Raleigh-Durham	60.7	11	New York City	34.7
4	San Diego	58.3	12	Minneapolis	34.5
5	Seattle-Bellevue	56.3	13	Denver	34.5
6	Maryland Suburbs / D.C. Metro	53.2	14	Chicago	30.7
7	Philadelphia	49.4	15	Central & Southern Florida	30.6
8	Los Angeles / Orange County	44.7	16	Long Island, N.Y.	30.0

Life sciences employment concentration:

Weight: 20.0%

Measured as the percent of industry employment against total metro private employment.

Life sciences employment growth:

Weight: 10.0%

Life sciences establishment concentration:

Weight: 10.0%

Measured as the percent of industry establishments against total metro private establishments.

Life sciences venture capital funding:

Weight: 15.0%

National Institutes of Health funding:

Weight: 15.0 %

Market Occupancy Rate:

Weight: 10.0%

Average Asking Rent (NNN):

Weight: 10.0%

Rentable Lab Supply:

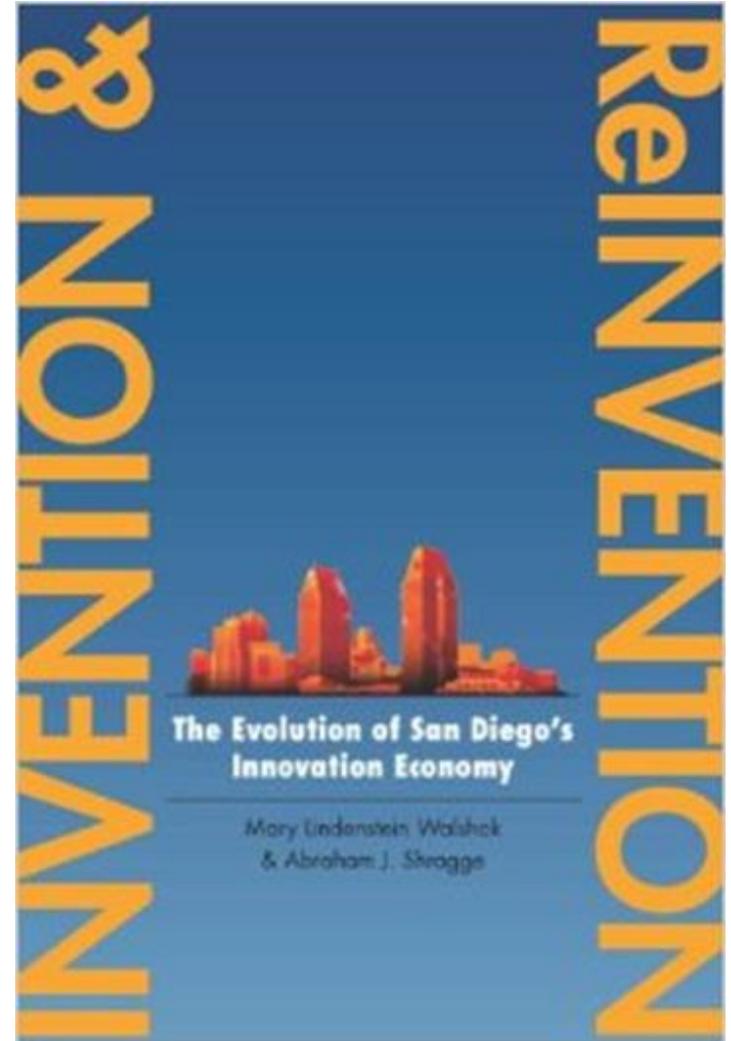
Weight: 10.0%

A caveat: risky and expensive investment in biotechnology does not always produce miraculous results....

- New products generated by biotech often seem to offer great benefits, but as the *New York Times* (10/29/2016) reports with regard genetically modified crops in the U.S., “the technology has fallen short of the promise.”
- A recent National Academy of Sciences report found that “there was little evidence” that GMO crops had led to yield gains beyond those seen in conventional crops; moreover, “the spraying of herbicides...has risen by 21%.”

The case of biotech in San Diego, California

- San Diego's biotech industry grew up over a long period of time. It was “made, not born.”
- Its roots can be traced to the 1850s, when settlers began migrating to the region for the sake of their health, believing that San Diego’s warm, dry climate might cure their asthma, tuberculosis, and bronchitis. (It didn’t, but they came anyway.)
- Still a very small town in 1900 (population 17,100), the business community constantly sought innovative ways to promote urban growth.



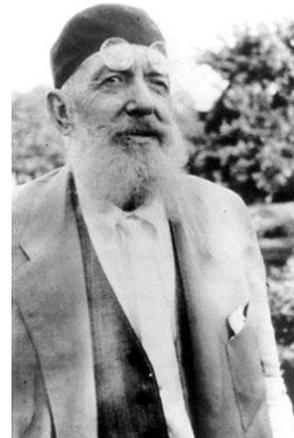
Generating urban and economic growth, early 20th century

- The Chamber of Commerce (CoC) urged the city government and voters to give prime land to the U.S. Navy so the Navy would build bases in San Diego.

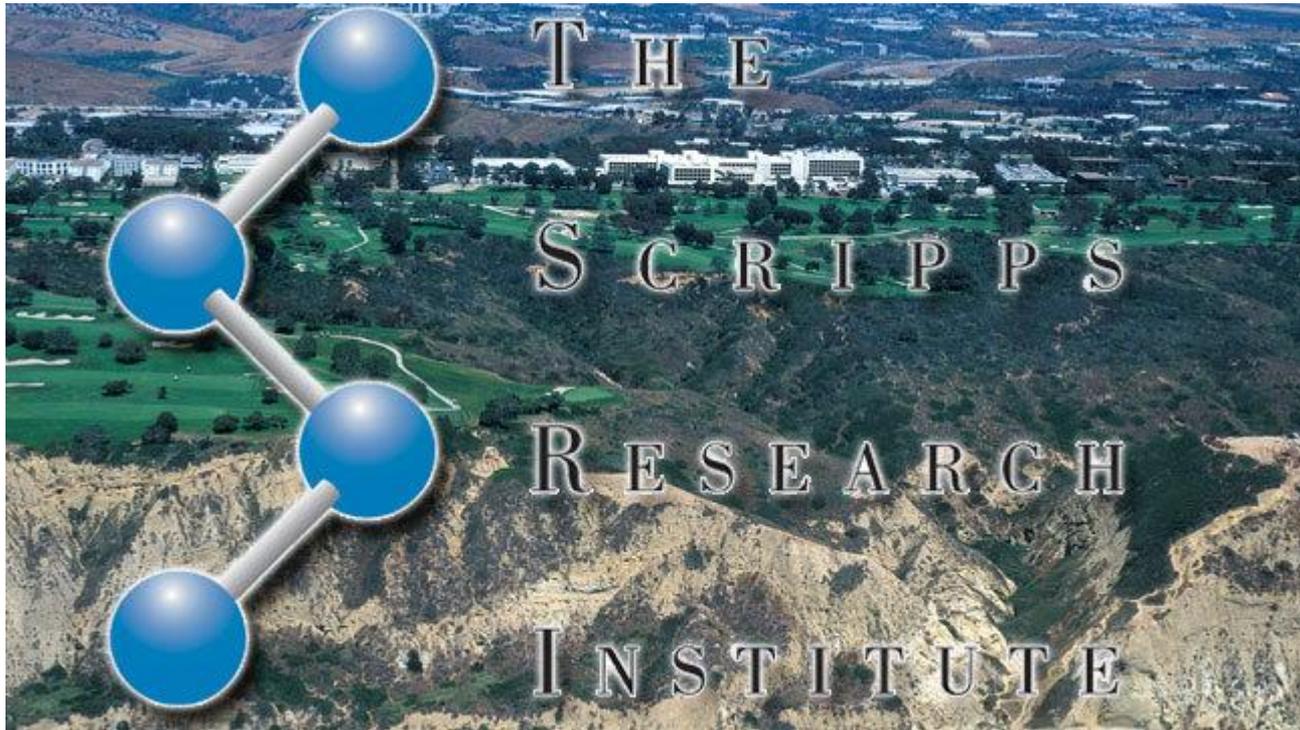


Marine Corps Recruit Depot under construction, 1921

- The CoC and individual civic leaders founded the Scripps Institution of Oceanography (originating in 1903), giving prime land to the University of California in the belief that a local reputation for scientific research and higher education would drive growth.



E.W. Scripps and Ellen B. Scripps



Another Scripps family legacy is **The Scripps Research Institute**, just “one more” world-renowned health-sciences endeavor in San Diego.

What made this and the others—**Hybritech**, the **Sanford Consortium for Regenerative Medicine**, the **J. Craig Venter Institute**, the **UCSD Clinical and Translational Research Institute**, the **Center for Algae Biotechnology**, **Sequenom**, **Stratagene**, the **Genomics Institute of the Novartis Foundation**, and MANY MORE—possible, was the climate of collaboration between business, the academy, the government, and ordinary citizens that is at the foundation of San Diego’s civic culture.

The World War II and Cold War years

- During the war, SIO scientists ran and staffed defense labs in San Diego, helping to win the war and building a strong foundation for postwar defense R&D.
- In the 1950s and '60s, the city gave away prime land on the Torrey Pines Mesa to the University of California, the Salk Institute for Biological Studies and others, and created the Torrey Pines Science Park, all in close proximity to one another.



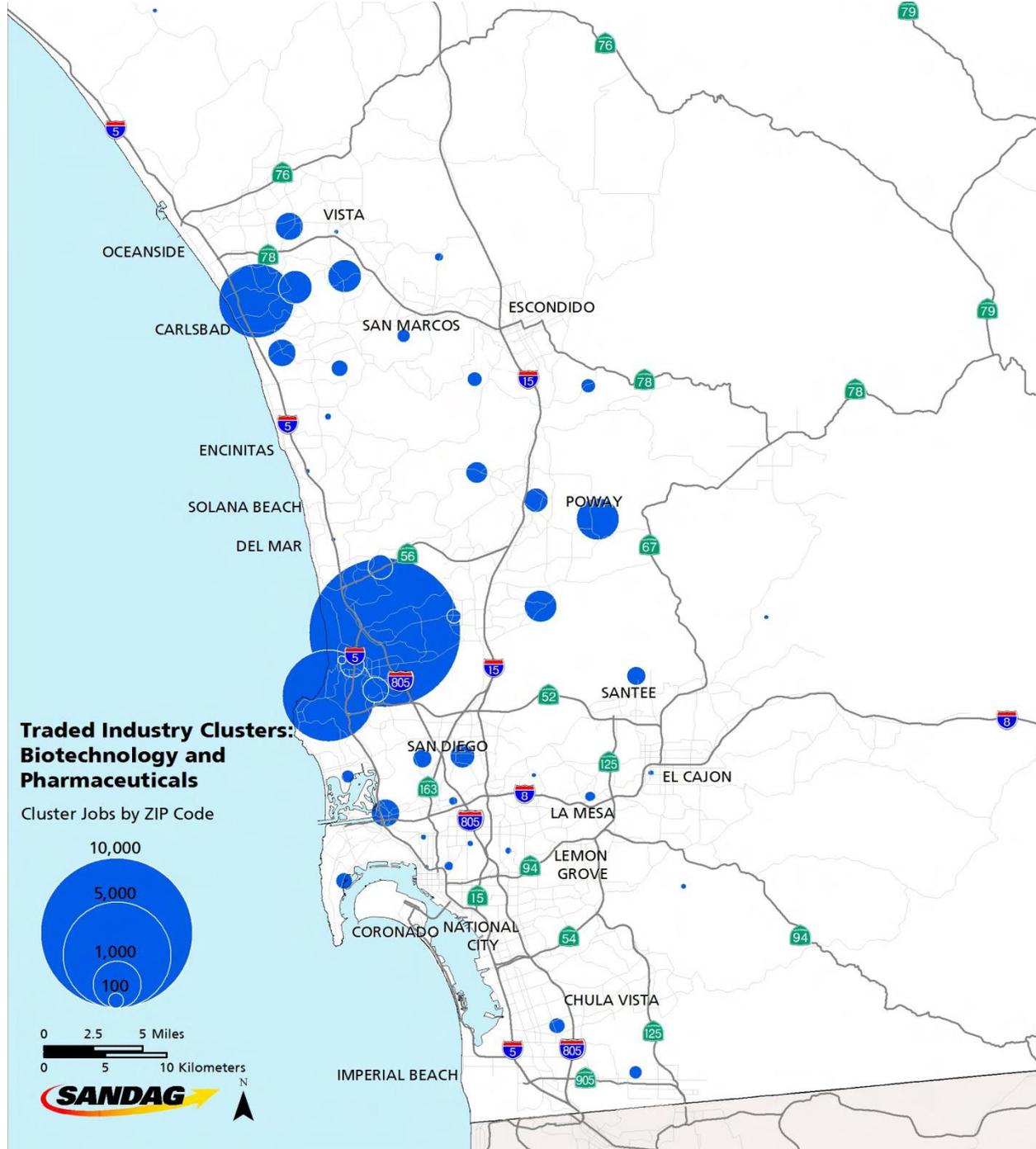
UCSD took over the former USMC rifle range on the Torrey Pines Mesa.



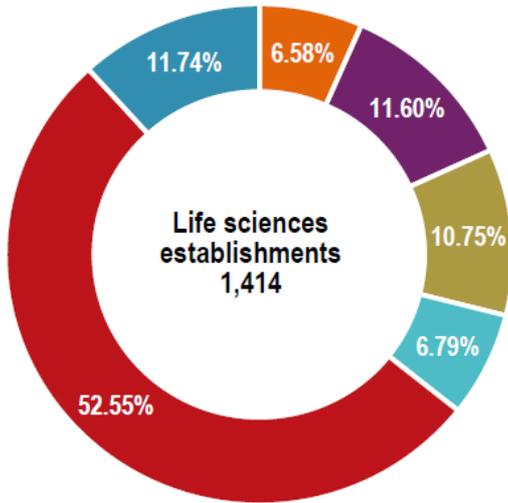
The Salk Institute for Biological Studies

Biotech clusters, 2010

Between 2008 and 2010, the height of the Great Recession, the Biomedical Devices and Products cluster grew 21%; and the Biotechnology and Pharmaceuticals cluster grew 20%.



Life sciences establishment composition



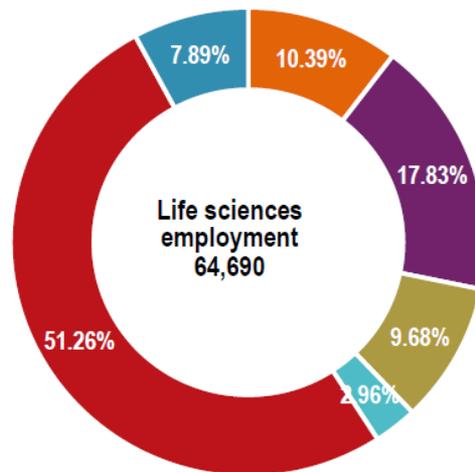
- Pharma & Medicine MFG
- Electromedical Instrument MFG
- Medical Equipment & Supplies MFG
- Testing Laboratories
- R&D
- Medical & Diagnostic Laboratories

San Diego has seen 6.0 percent year-over-year growth in life sciences patents. With San Diego being home to many medical device companies and UCSD offering a masters program in medical device engineering, it is not surprising that medical equipment and instruments patents increased at a faster pace (17 percent year-over-year).

San Diego's biotech sector continues to show strong growth into 2016.

Life sciences employment grew at a faster rate than total private employment, 5.6 percent compared to 2.7 percent, respectively. The notable life sciences cluster is partly attributable to the presence of some of the world's largest biotech, pharmaceutical, and non-profit research institutes. Moreover the University of California, San Diego has strong science and engineering programs that produce a number of scientists.

Life sciences employment composition



- Pharma & Medicine MFG
 - Electromedical Instrument MFG
 - Medical Equipment & Supplies MFG
 - Testing Laboratories
 - R&D
 - Medical & Diagnostic Laboratories
- non-lab using
- lab using

Key takeaways from the San Diego experience:

1. Developing San Diego into a leading center for biotechnology education, R&D and manufacturing was a long term, bottom-up, organic process.
2. It required immense political will for the city to invest so much of its primary economic asset—its prime real estate—in the form of donations to institutions and companies.
3. The attractions of the place itself—its warm, dry climate; its natural beauty; its innovative civic culture—were key to the long-term success of the cluster's development.
4. Biotech's strength in San Diego rests on a combination of basic research, applied research, marketing, and institutional/community collaboration—attributes worth emulating.

References

- Mary L. Walshok and Abraham J. Shragge, *Invention and Reinvention: The Evolution of San Diego's Innovation Economy* (Stanford, 2013).
- Robert Carlson, "Estimating the Biotechnology Sector's Contribution to the US Economy," *Nature Biotechnology* (34) 3, March 2016.
- JLL, (Jones Lang Lasalle IP Inc., "Life Sciences Outlook, 2016," <http://www.us.jll.com/united-states/en-us/research/life-sciences-companies/trends>
- EY (Ernst & Young) "Beyond Borders: Reaching New Heights, Biotechnology Industry Report, 2015," [http://www.ey.com/Publication/vwLUAssets/EY-beyond-borders-2015/\\$FILE/EY-beyond-borders-2015.pdf](http://www.ey.com/Publication/vwLUAssets/EY-beyond-borders-2015/$FILE/EY-beyond-borders-2015.pdf)
- SANDAG (San Diego Association of Governments), <http://www.sandag.org/>
- Richard Florida, *The Rise of the Creative Class: and How It's Transforming Work, Leisure, Community, and Everyday Life* (Sage Publications, 2002).

Thank you!

