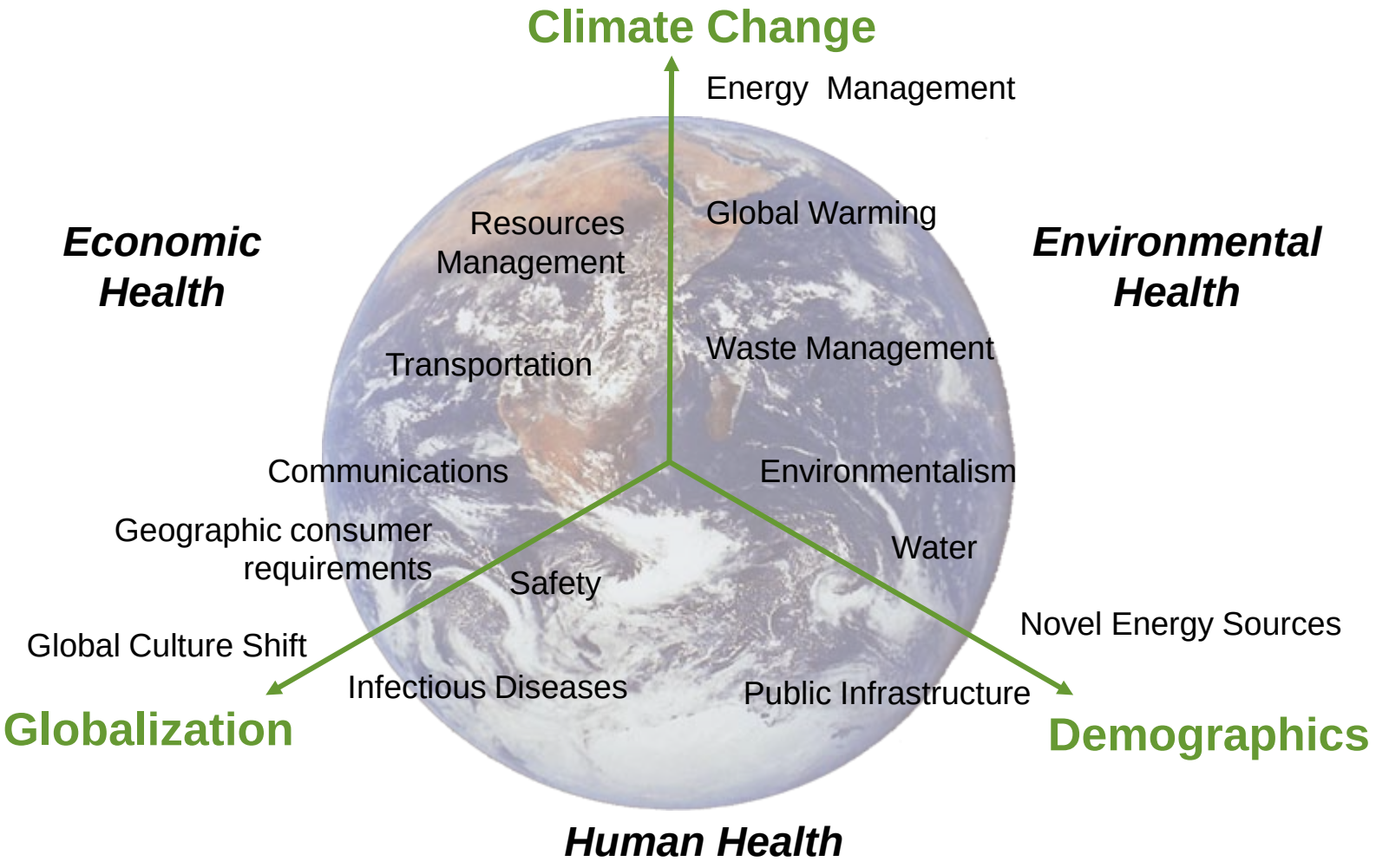
Engineering the Life Sciences

Darlene J.S. Solomon, Ph.D.
Senior Vice President and Chief Technology Officer
Agilent Technologies

Multidisciplinary Contributions

- Critical to the World and Agilent
- Successful Examples
- Moving Forward

Drivers of Global Dilemmas



Need for Multiple Disciplines

In Academia and Industry

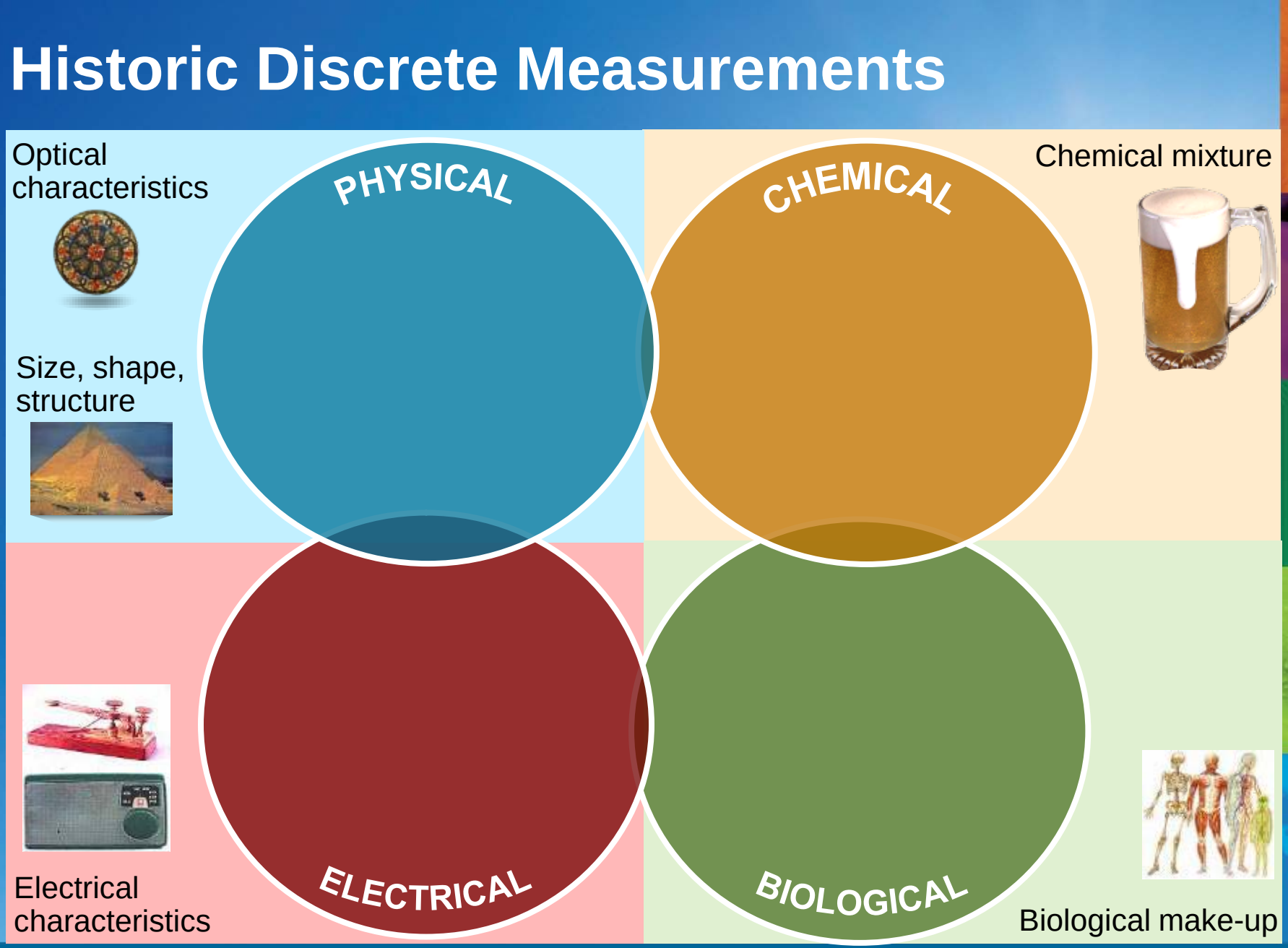
"The evolution of … electrical and computer engineering demands a new breed of ECE graduates with a broad set of competencies that cannot be … constrained by traditional boundaries."

"Electrical and Computer Engineering for a New Generation"
By T.E. Schlesinger and B. Krogh
ECEDHA Source, Issue 4, Spring 2010

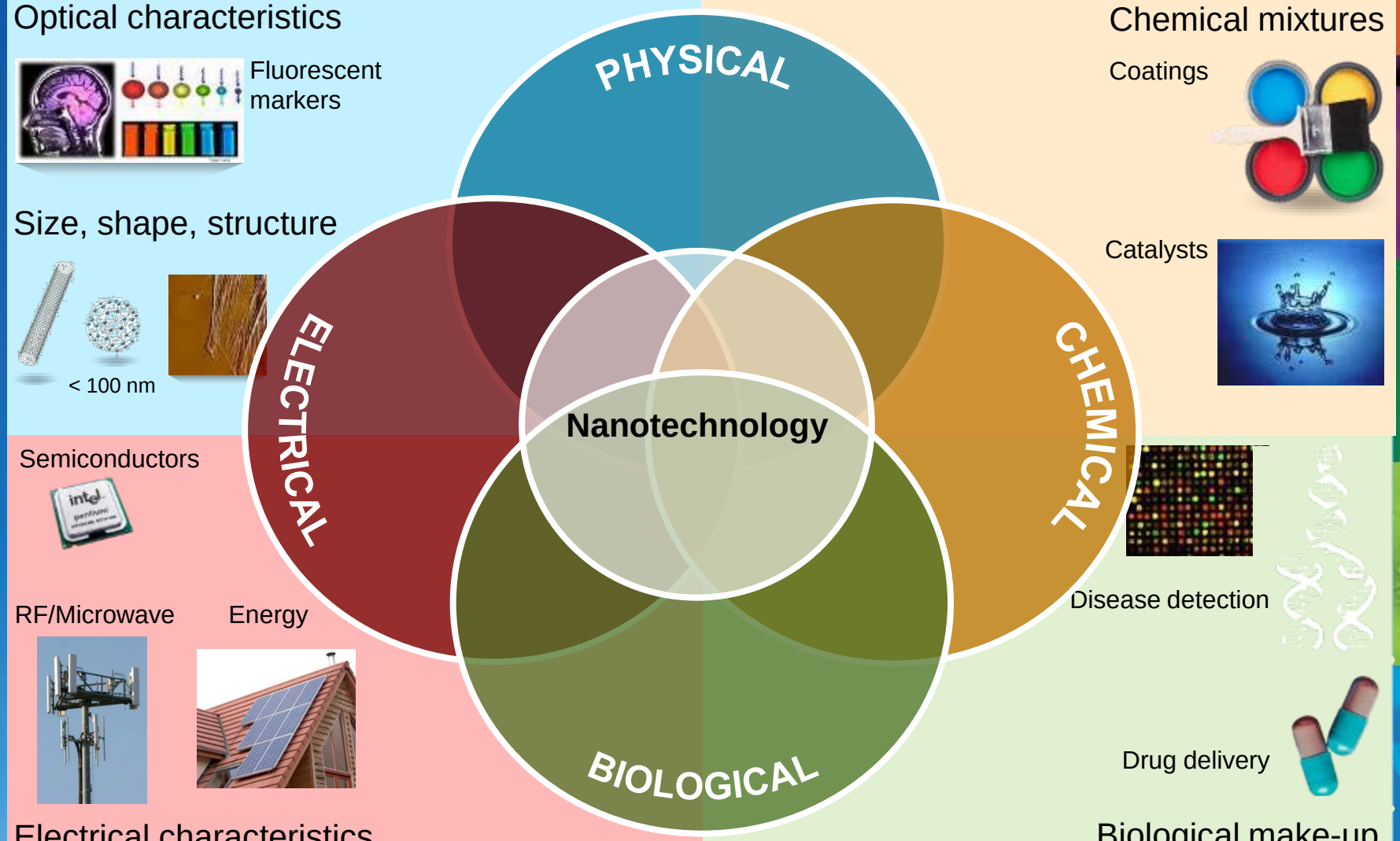
Biomedical Engineer – the fastest growing job, a relatively new specialty that bridges medical and engineering disciplines such as math, chemistry, physics, biology and engineering

"Top 10 List: Where the Jobs Are"
by Cecilia Simon
New York Times, April 13, 2011

Historic Discrete Measurements



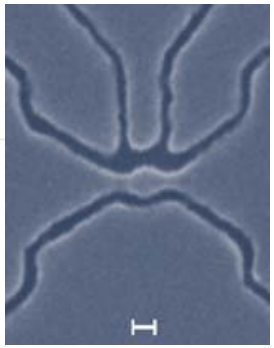
Current Converging Measurements



Electronics / Biology Convergence

Engineering at the Nanoscale

Graphene Quantum Dot Device
University of Manchester
20nm



Electronics

Scaling down to reach nanoscale

Nanotechnology

Integration & Miniaturization

Scaling up to reach nanoscale

Biology

Complexity

Nanomotor: ATP Synthase
Boris A. Feniouk, www.atpsynthase.info

Science & Measurement Are Inextricably Linked

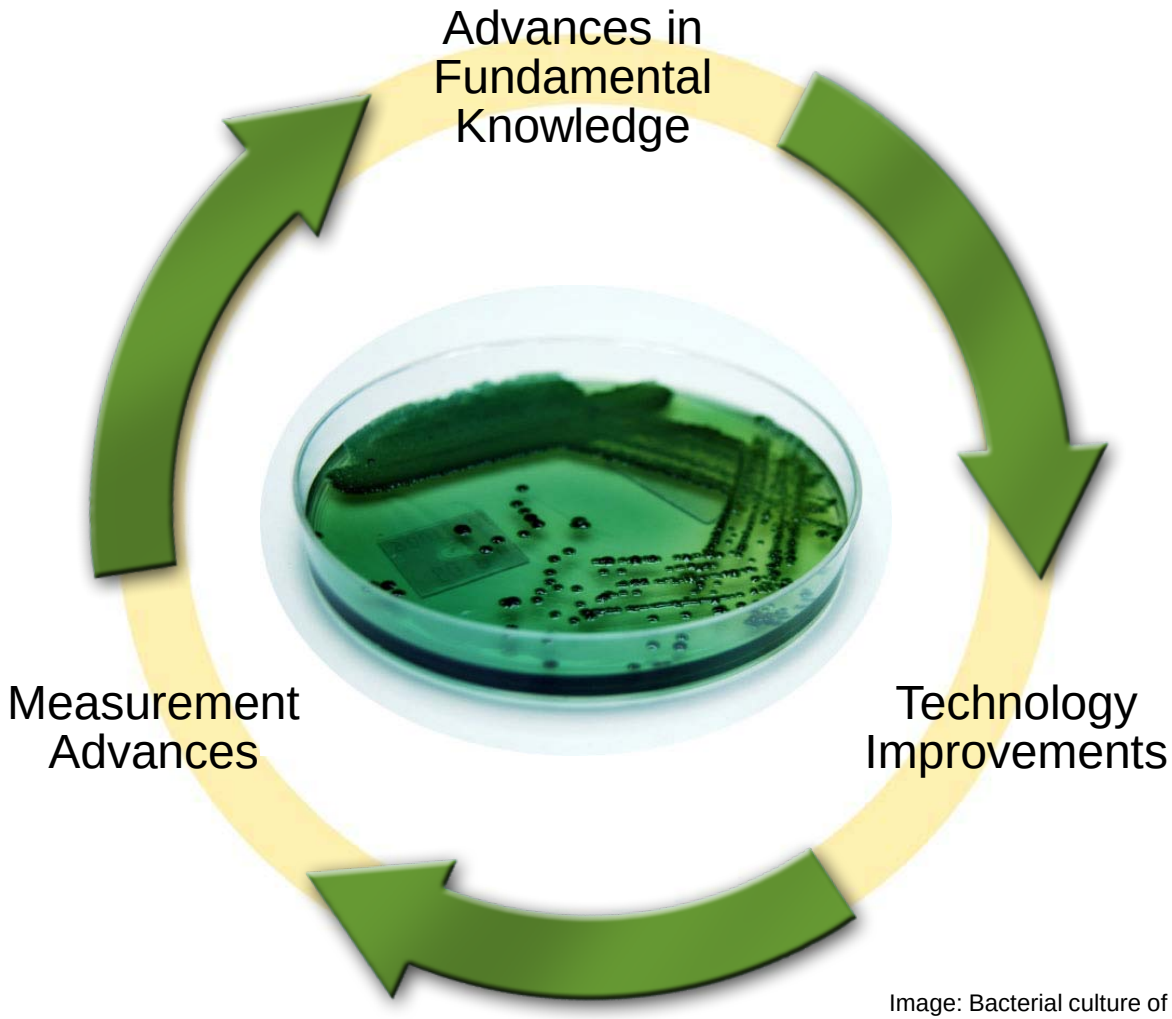
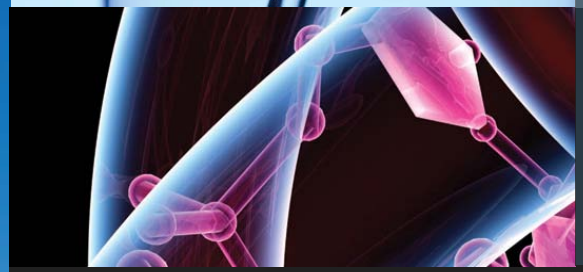


Image: Bacterial culture of aeromonas hydrophila

Agilent's Businesses

Opportunities for Multidisciplinary Teamwork

		FY11 Revenue
	Electronic Measurement Group	$3.3B
	Chemical Analysis Group	$1.5B
	Life Sciences Group	$1.8B
		$6.6 B

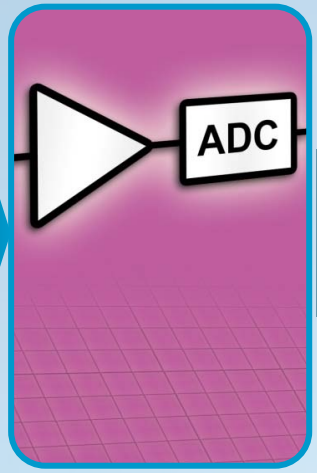
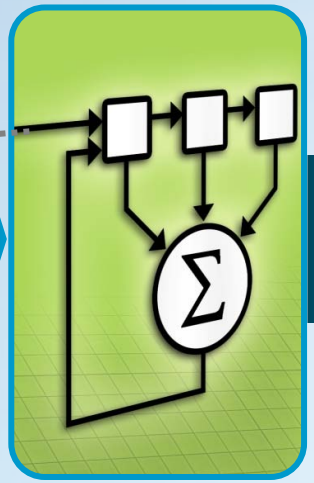
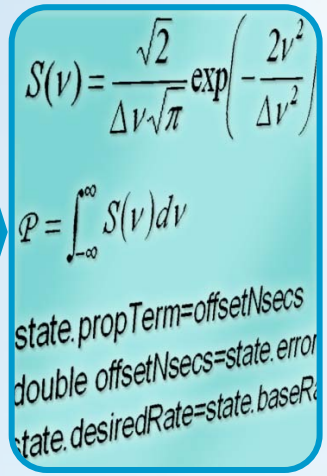
Agilent Research Laboratories

Enabling technology breakthroughs and synergies across Agilent

Measurement: Agilent's Core Contribution

Digital Fundamentals Apply Across Multiple Businesses

Application Specific

Sample	Detect/Acquire	Analyze (What is that signal?)	Integrate (What is it doing?)	Interpret (What does it mean?)
				
Physical Analog Measurement	Signal Conditioning and Data Conversion	Digital Signal Processing and Signal Correlation	Measurement Science in System Context	Data Management, Visualization and Decision Analysis

National Cancer Institute, Pathology Histology Breast Cancer
iStock Photo, Circuit Board

Agilent Technologies

Addressing Critical Measurement Challenges

Electronic Measurement

- Wireless technologies
- Mobile phone R&D and manufacturing
- Aerospace/defense
- Low-cost instrumentation

Chemical Analysis

- Food safety, quality
- Energy research, production
- Quality of air, water, soil
- Forensics, drugs of abuse

Life Sciences

- Pharmaceutical research and manufacturing
- Genomics, proteomics, metabolomics tools for disease research

Agilent Research Laboratories

Competitive Advantage Through Technology

Applied research

Breakthrough technologies

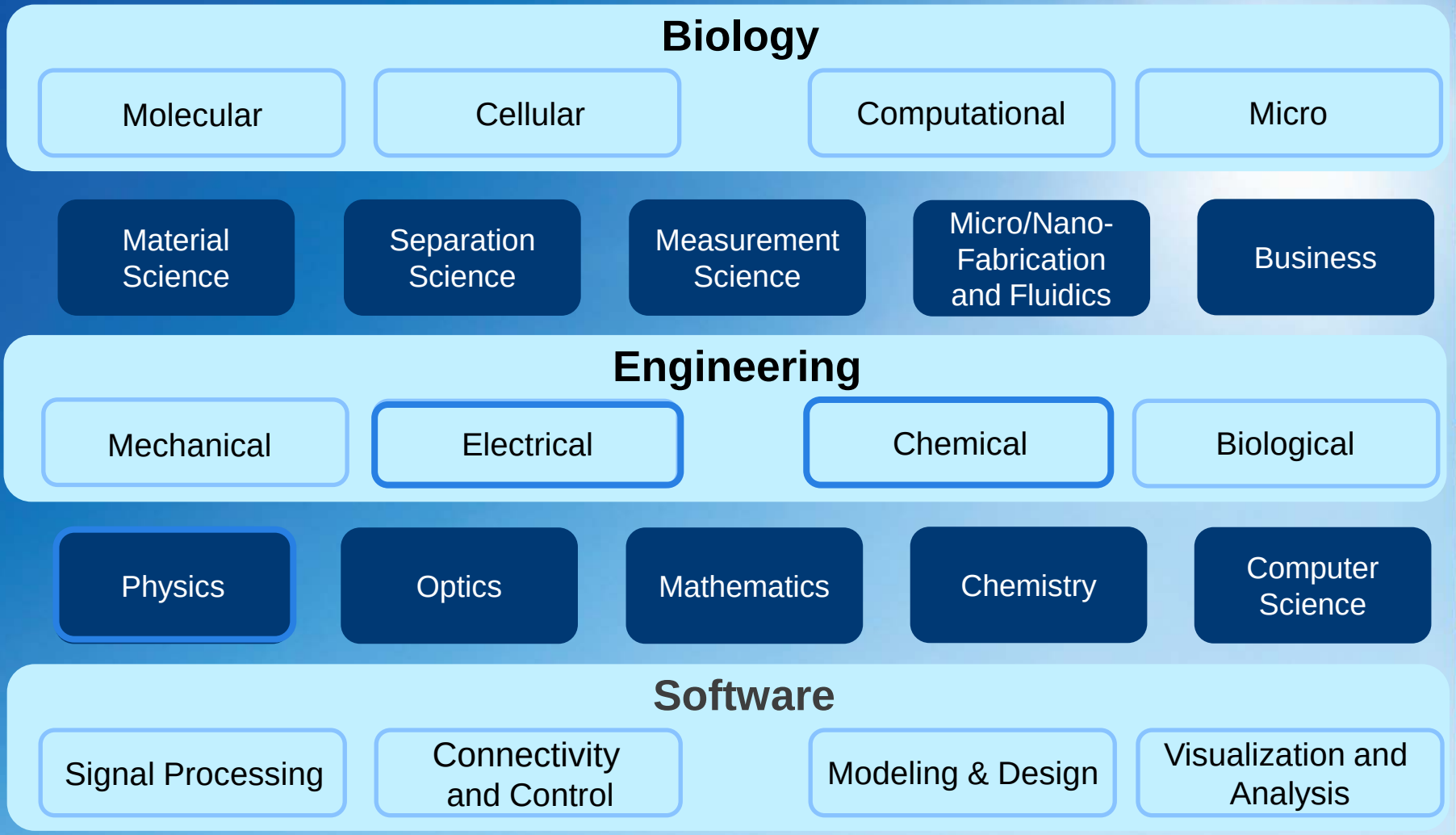
Measurement synergies

World-class research teams across interdisciplinary, global organization

Collaboration with leading academic, government & industrial researchers

Partners to Agilent's businesses in R&D commercialization

A Diversity of Research Disciplines



Key Innovation Partners

About 100 Active University Collaborations Annually

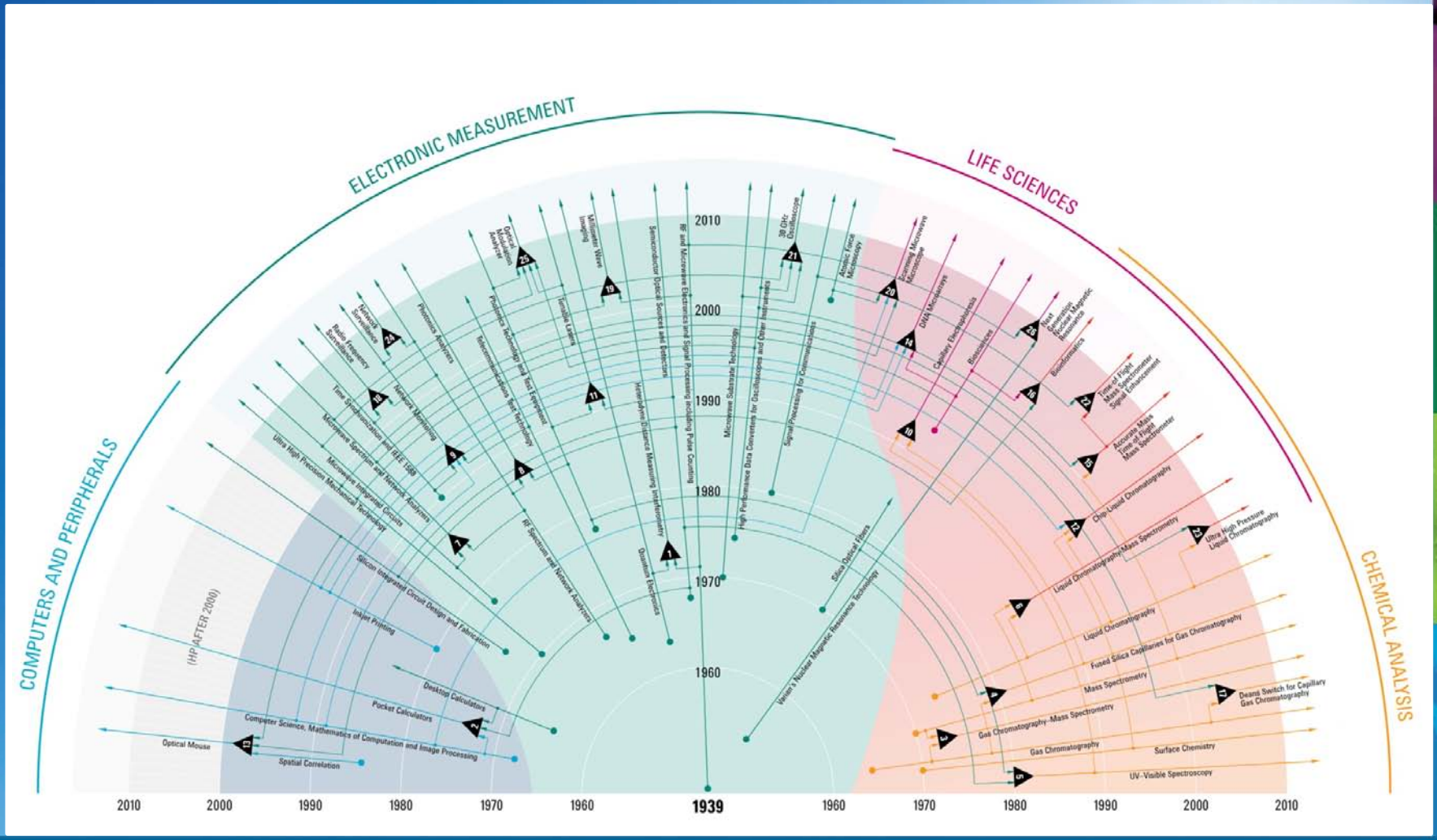
Multidisciplinary Contributions

- Critical to the World and Agilent
- **Successful Examples**
- Moving Forward

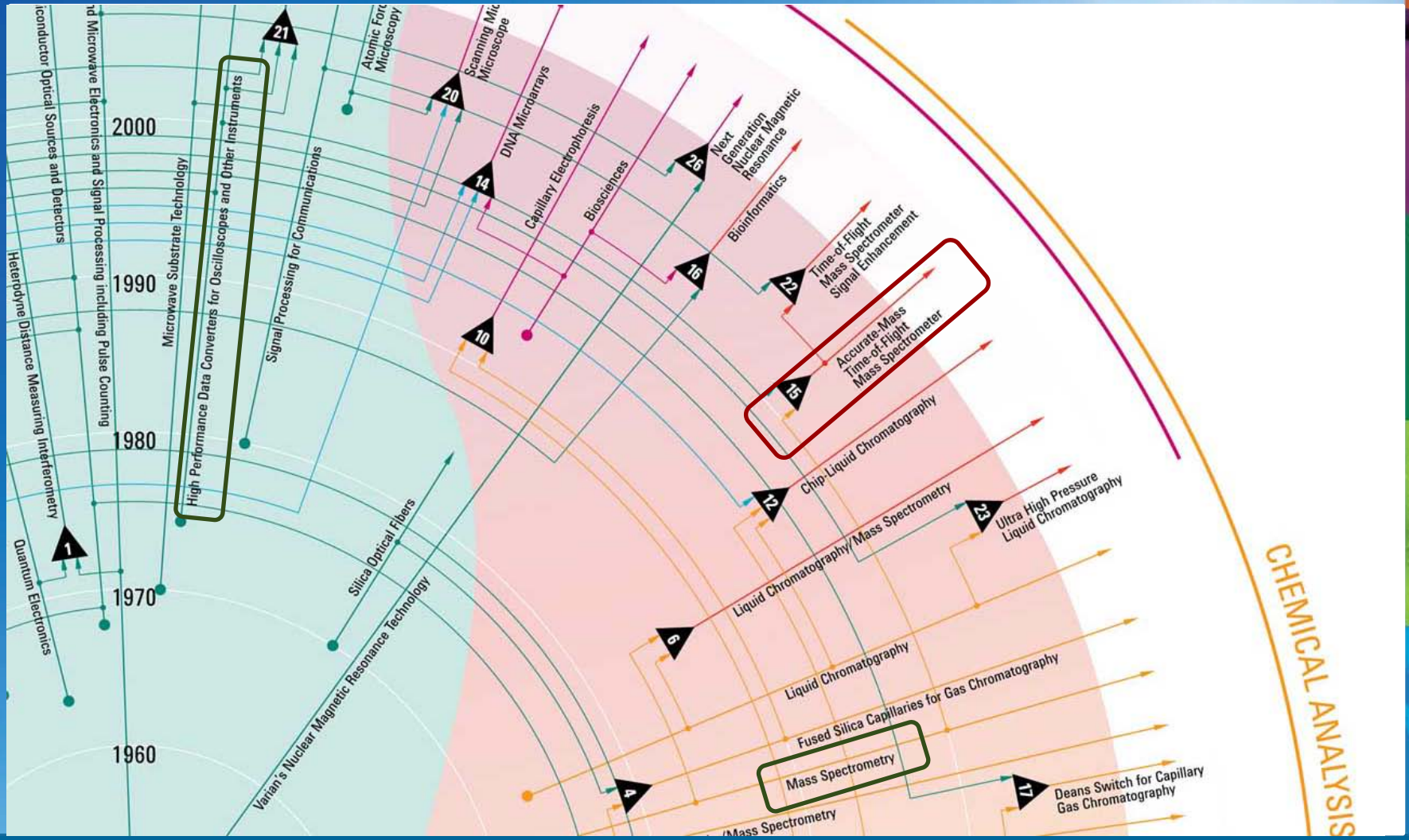
Synergy Drives Innovation

Synergy: two or more components working together to produce a result not obtainable by any of the components independently

Agilent: Seven Decades of Innovation Across Boundaries



Synergy 15:
Accurate-Mass Time-of-Flight Mass Spectrometer



2000s: Electronic Data Converter ICs Speed Mass Spectrometers

Agilent 6550 iFunnel Quadrupole Time-of-Flight Liquid Chromatography Mass Spectrometry System

Accurate-Mass Time-of-Flight Mass Spectrometer

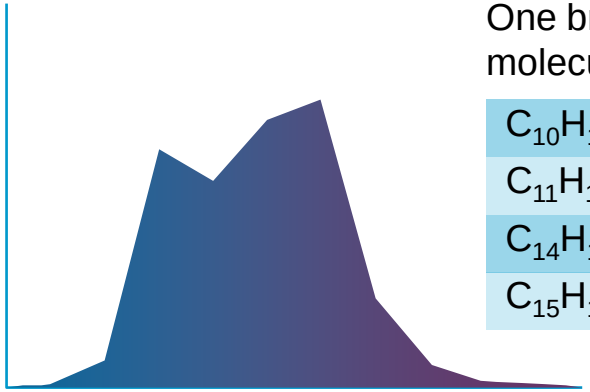
- 1970: Entered mass spectrometry business with quadrupole mass filters
- Today Agilent mass spec systems lead in performance and leverage our high-speed oscilloscope platform
- Both are *critically dependent* on high-speed data conversion and digital signal processing.
- Agilent is the only mass spectrometry company not limited to data converters available commercially
- Improved analysis of complex proteomic and metabolomic samples and biomarker discovery

The most sensitive instrument in its class…
pushes the limits of detection and identification to new, unprecedented levels

Electronic Research Aids Bioanalytical Customers

Faster Digitization Leads to Unambiguous Molecular Analysis

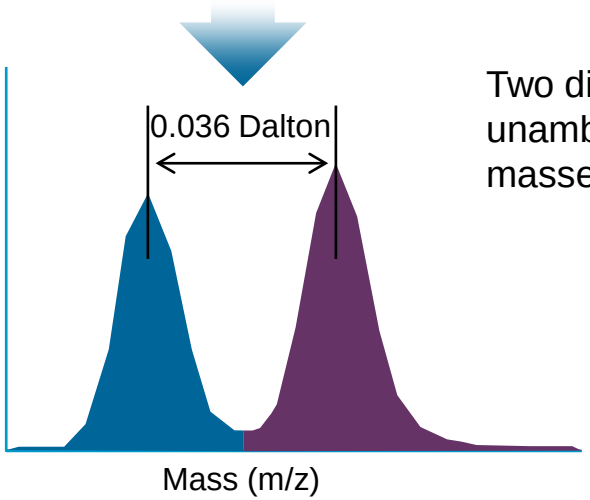
Molecules are hard to identify with slow speed (1 GSa/s), low resolution time of flight mass spectrometers



One broad peak with 4 possible molecular formulas

$C_{10}H_{10}O_4$
$C_{11}H_{14}O_3$
$C_{14}H_{10}O$
$C_{15}H_{14}$

High-speed (4 GSa/s), high resolution time of flight mass spectrometers separate molecules and identify their masses accurately

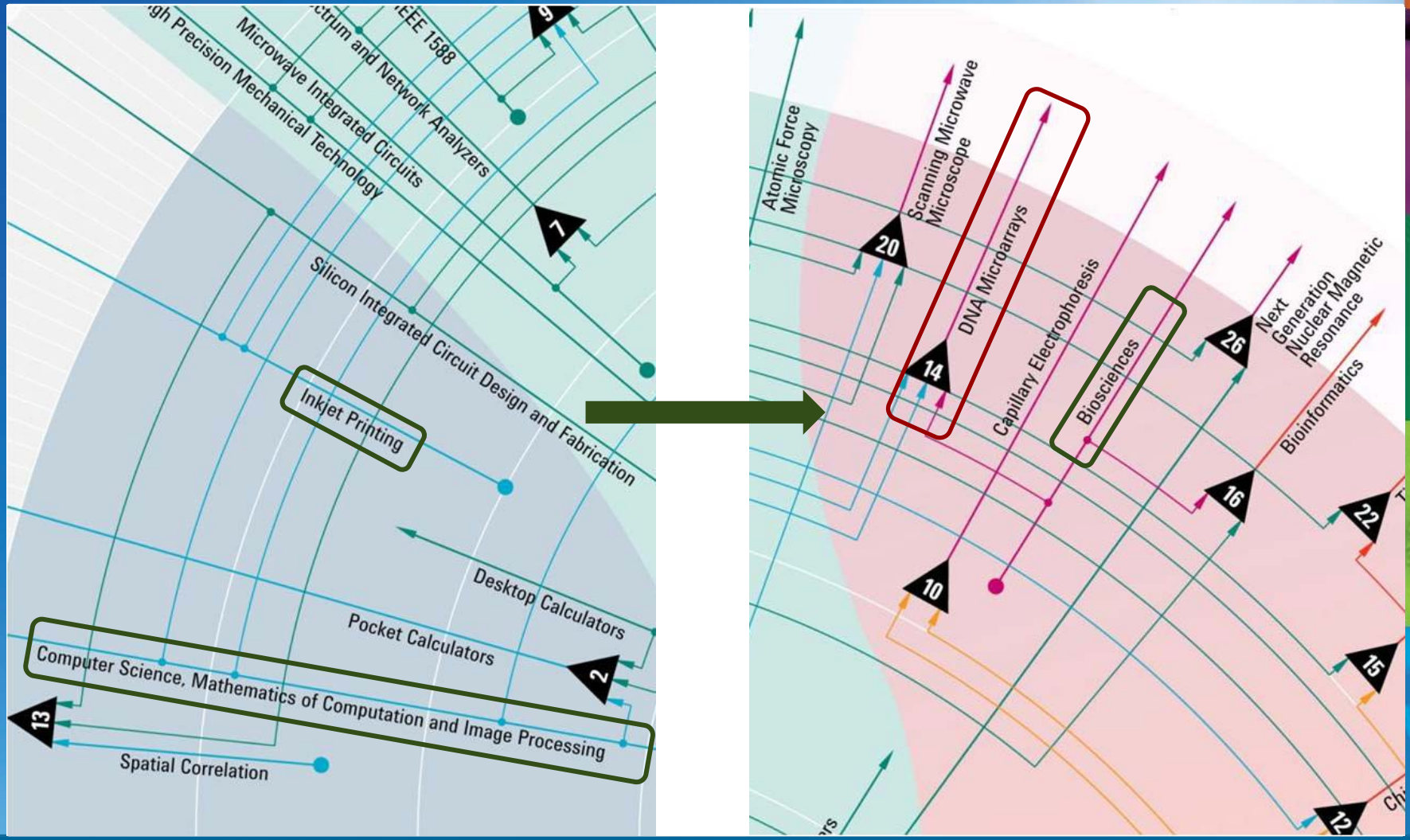


Two distinct peaks with unambiguous molecular masses

Agilent Mass Spectrometers Detect Pharmaceutical and Cosmetic Pollutants

- Keeping water clean requires ability to identify and quantify pollutants.
- Thousands of chemical substances have been found in sewage and reclaimed water for irrigation:
  - antibiotics
  - cosmetics
  - pain killers
  - over-the-counter drugs
- Very low concentrations aren't considered dangerous short term, but no one knows the long-term human and ecological effects.
- Research and government agencies use Agilent instruments to investigate and develop effective strategies to remove these pollutants

Synergy 14: DNA Microarrays



Agilent Technologies

2000s: Inkjet Printing Meets Nucleic Acids

Agilent Microarray

DNA Microarrays

- Agilent's expertise in DNA biochemistry, image analysis and inkjet printing (from HP) was key to development of DNA microarrays for genomic analysis.
- Inkjet synthesis of 60-200mer length probes *in situ* provide superior performance
- Virtual grid of up to 1,000,000 features on a standard slide; any format, any density, any sequence on demand.
- Agilent continues to advance technology and create new research applications and businesses; RNA therapeutic manufacturing and target enrichment for DNA sequencing.

Advancing sophisticated tools for examining the genomic aspects of cancers and other illnesses

Agilent Microarrays Advance Research of Developmental Disorders

- Researchers can study structures and functions of chromosomes with high accuracy and resolution.
- Analysis of genomic changes advances research for Down syndrome, autism and cancer.
- Research goals: to understand cell function and diagnose genetic disorders more precisely

Agilent's DNA Microarray Timeline

Platform Investments Drive Breakthrough Contributions

2012: "See" RNA, DNA in cells

2011: Detect copy number and copy-neutral aberrations

2010: Study 49,000-year-old Neandertal DNA

2009: Sequence specific genomic areas

Microarrays include up to 1M probes

Arrays to study human Copy Number Variation

2007: Agilent microarray is first to gain FDA approval

Profile human microRNAs

2005: Microarray for human comparative genomic hybridization

2004: Locate genetic alterations related to cancer and developmental disorders

Microarray to study whole human genome

2000: Agilent ships first DNA microarrays

1992: DNA microarray research begins in Labs

Multidisciplinary Contributions

- Critical to the World and Agilent
- Successful Examples
- **Moving Forward**

Driving the Future of Measurement

Multidisciplinary Contribution Will Be Increasingly Pervasive

Energy and the Environment

Advancing High Growth Economies

Portable, Mobile and Out-of-Lab

Nanotechnology

Food Safety

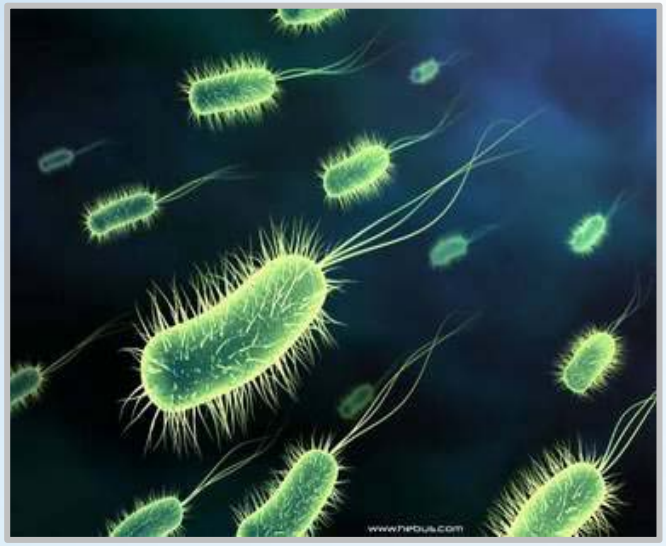
Personalized Medicine

Single Cells and Microbiome

Synthetic Biology

The Next Frontier: Synthetic Biology

- Transform research practices and manufacturing processes within the $100B industrial biotechnology and biomedical markets
- “Engineer” biological systems
  - Bacteria
  - Fungi
  - Cell-lines
  - Plants, Algae
- Manufacture useful products and high-value intermediates
  - Pharmaceuticals
  - Chemicals
  - Biofuels
- Greener, more sustainable alternatives to traditional methodologies

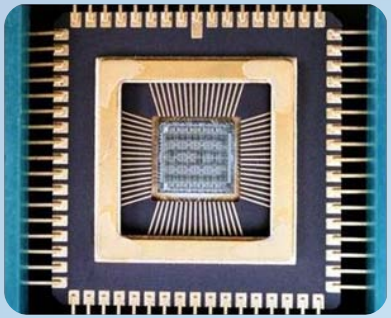


3D rendering of bacteria that could be genetically altered or engineered

Synthetic Biology: Next Electronics Industry?

The redesign of biological systems and their component parts for useful and practical purposes

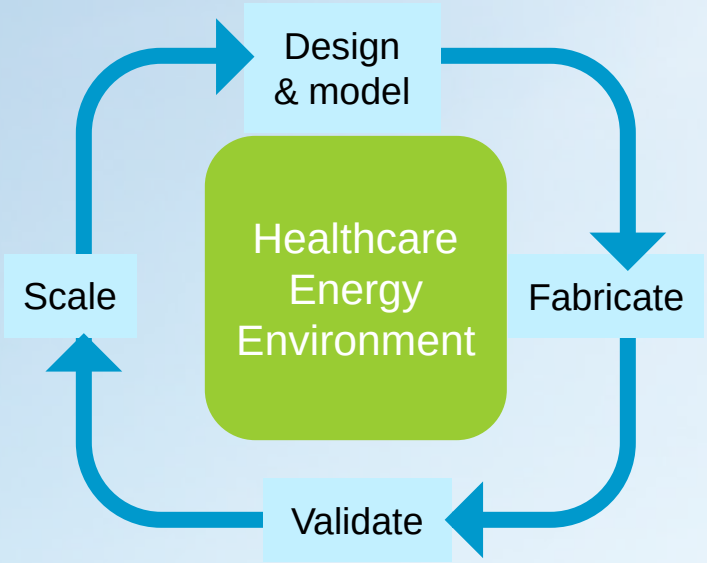
Standardized integrated electronic parts & devices



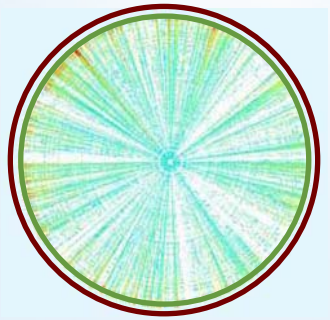
Integrated circuit

Tools for IC Fab

Well developed for maturing industry



Standardized integrated biological parts & devices



Synthetic genome

Tools for SynBio

Requires revolutionary technologies

Innovation Challenges

For Technology Educators and Leaders

Teamwork

- Days of the lone inventor working heroically are diminishing
- Innovations often part of complex systems and solutions
- Our connected world and competition are moving faster than ever

Multiple disciplines

- Excellence in each of many areas
- Communication across disciplines

Supportive environment

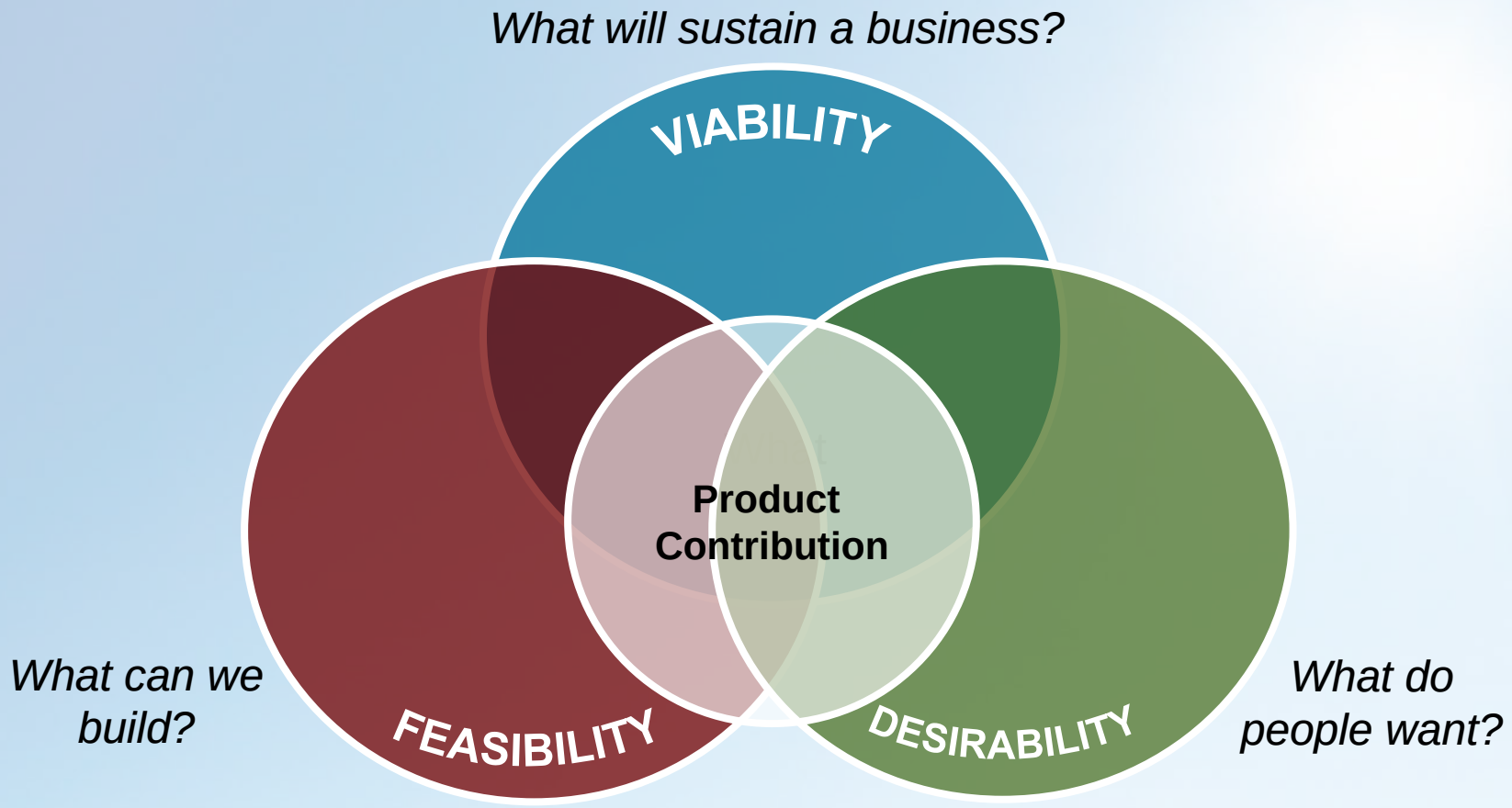
- A culture that challenges the status quo
- A culture that tolerates failure; freedom from fear

Enlightened leadership

- Leaders can command obedience, not passion
- Trust, patience and commitment to diversity

Technology Innovation is Not Enough

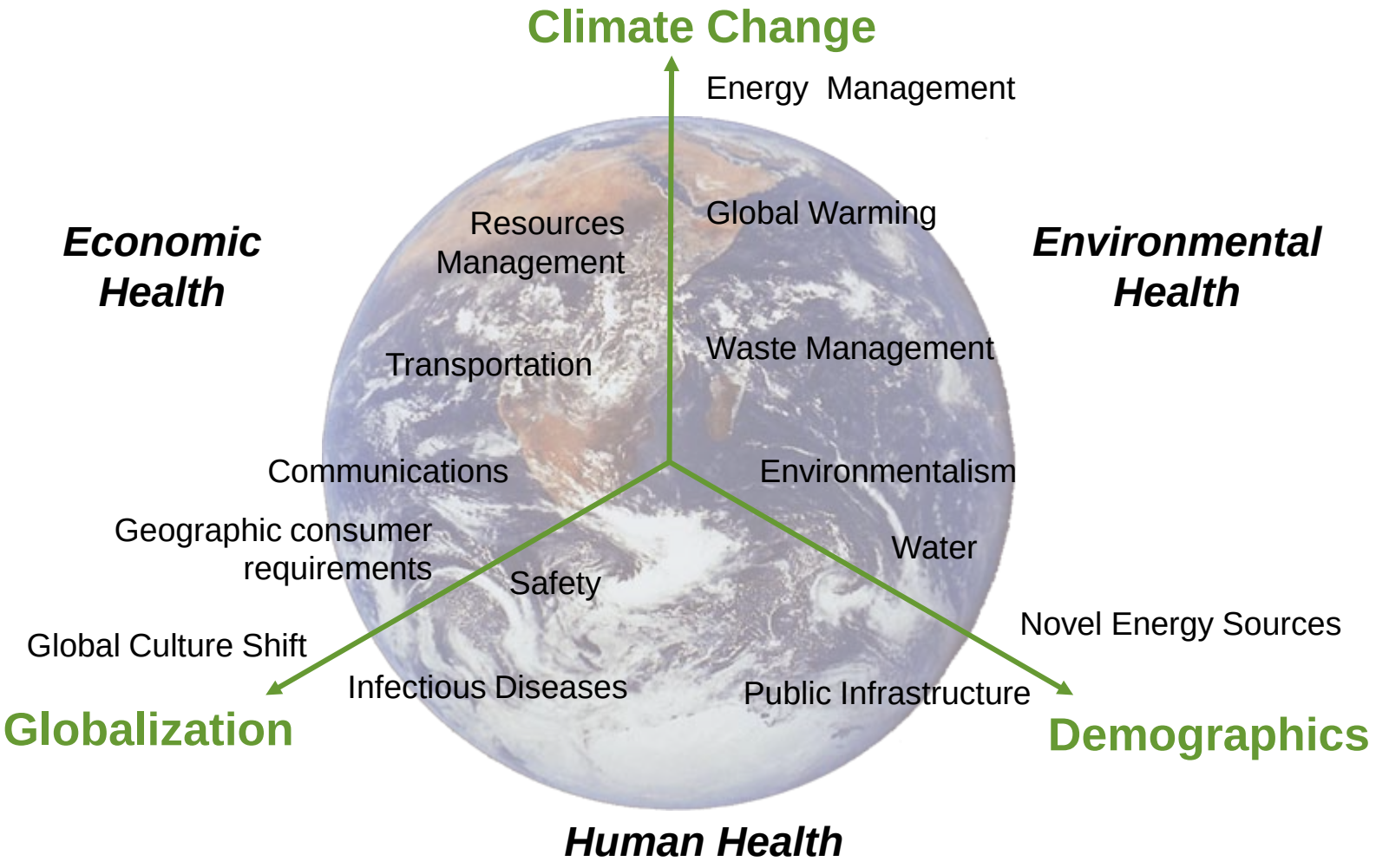
For Meaningful Product Contribution



From Hugh Dubberly, AIGA Journal of Design for the Network Economy, 2001

Multidisciplinary Contribution

Opportunities to Address Problems That Matter



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