

# Choosing to Lead:

## The Race for National R&D Leadership & New Economy Jobs

Core Technology Strengths  
and  
Strategic University-Industry Alliance  
Opportunities

The Massachusetts Technology Road Map and  
Strategic Alliances Study

2004

**Battelle**

**Mi** Mass Insight  
CORPORATION

## Nine Potential Strategic Alliance Opportunities\* Identified in "Choosing to Lead"

Many of these strategic alliance opportunities cut across the ten core technology areas where Massachusetts is a national leader.

STRATEGIC ALLIANCE	CORE TECHNOLOGY FOCUS AREAS DRAWN UPON	INDUSTRIES AFFECTED	REGIONS AFFECTED
Nanoscale Device Fabrication Facilities Network	Advanced materials Sensing, Optical, Electro-mechanical Devices Life Sciences	IT Telecom Biotech Medical Devices Advanced Manufacturing	Greater Boston Northeast Pioneer Valley
Smart Materials Technology Incubator	Advanced Materials	Medical Devices Advanced Manufacturing	Greater Boston Northeast Southeast Pioneer Valley
Neuroscience Systems Biology Consortium	Life sciences Computer Sciences	Biotech Medical Devices	Central Greater Boston Pioneer Valley
Biogrid	Computer Sciences Life Sciences	IT Telecom Biotech Pharmaceuticals Health Care	Central Greater Boston Pioneer Valley
Next Generation Sensing and Imaging Testbed	Sensing, Optical, Electro-mechanical Devices Signal Processing Computer Sciences	IT Telecom Biotech Medical Devices Advanced Manufacturing	Central Greater Boston Northeast Pioneer Valley Berkshire
X-ray Laser Facility for Next Generation Imaging	Advanced Materials Genomics and Proteomics	Electronics Biotech Materials	Greater Boston Central Pioneer Valley
Integrated Communications-IT Platform for Emergency Response and Command Control	Signal Processing Computer Sciences Environmental Science	IT Telecom Defense	Central Greater Boston Southeast (ports) Pioneer Valley Berkshire Cape and Islands
Industrial Biotechnology and Clean Technologies	Advanced Materials Environmental Science	Advanced Manufacturing	Greater Boston Northeast Southeast Pioneer Valley Cape And Islands
Ocean Exploration and Management R&D Consortium	Life Sciences Environmental Science Computer Sciences Sensing, Optical, Electro-mechanical Devices	Biotech Fisheries Environmental	Greater Boston Southeast Cape And Islands

\*Each of these potential strategic alliance opportunities is presented in greater detail in Part II of *Choosing to Lead*.

While these opportunities are significant and promising, it should be kept in mind that **they are not exhaustive**. They demonstrate the range of opportunities available to Massachusetts and help inform approaches for realizing these opportunities. Each should be the subject of a further due diligence study to determine its feasibility, including how best to leverage existing state match funds to secure the more substantial federal and private commitments that would be required.

## Massachusetts' Ranking in Ten Core Technology Focus Areas

### Summary of Massachusetts Position in Core Focus Areas Across Industry, Talent and Research Measures: State Rankings

	INDUSTRY PRESENCE		TALENT GENERATION		RESEARCH EXCELLENCE	
	Number of firms	Employment controlled by Massachusetts firms	Total degrees awarded, 2001	Change in degrees awarded, 1996 to 2001	Total state funding in related-university research fields	Leading institutions in total citations (top 25 in nation) and reputational rankings for related fields
<b>Advanced Materials</b>	◐ 6th	⊖ 12th	◐ 7th	⊖ 36th	◐ 10th in metallurgical and materials engineering	MIT UMass Amherst Harvard
<b>Signal Processing</b>	● 2nd	◐ 8th	◐ 9th	⊖ 17th	◐ 6th in electrical engineering	MIT Harvard
<b>Computer Sciences</b>	● 2nd	◐ 9th	◐ 8th	⊖ 16th	◐ 6th in computer sciences	MIT Harvard UMass Amherst Boston University
<b>Sensing, Optical and Electro-mechanical Devices</b>	● 3rd	⊖ 11th	◐ 8th	⊖ 22nd	● 5th in mechanical engineering	MIT
<b>Environmental Sciences</b>	● 3rd	◐ 10th	◐ 8th	⊖ 38th	● 3rd in earth sciences	MIT Harvard
<b>Genomics and Proteomics</b>	● 2nd	◐ 9th	◐ 7th	⊖ 43rd	N/A	Harvard MIT Tufts UMass Worcester
<b>Disease Research and Drug Discovery</b>	● 3rd	◐ 9th	◐ 6th	⊖ 39th	N/A	Harvard/Partners Boston University Tufts UMass Worcester
<b>Biomedical Devices and Instrumentation</b>	● 2nd	● 4th	◐ 8th	⊖ 38th	N/A	MIT Harvard
<b>Renewable Energy</b>	● 3rd	⊖ 16th	◐ 8th	⊖ 25th	N/A	MIT
<b>Nanotechnology*</b> Nanotechnology fabrication*	N/A	N/A	N/A	N/A	N/A	MIT Harvard UMass Amherst

● Leader Ranking 6–10 = ◐ Challenger Ranking 11–up = ⊖ Follower

- Industry presence based on CorpTech data.
- Talent generation based on National Center for Educational Statistics data.
- Research excellence based on NSF data on university research funding, publications data from Institute for Scientific Information and reputational survey rankings from US News & World Report.
- \*Nanotechnology rankings based on recent NSF funding awards under the National Nanotechnology Initiative for top institutions, FY2001–03.

*Refer to the pages that follow for more detail on each of these core technology focus areas.*

# ADVANCED MATERIALS

**WHAT IS IT?** The development of new classes of materials with unusual properties (e.g., strength, wear characteristics, and electromagnetic properties) are expected to open up a broad range of opportunities leading to next generation machines, improvements in product performance and cost, and waste-free products. Typical research activities include the processing of metals, ceramics, and composite materials with a specific focus of working at the nanoscale level.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** With a strong concentration in patent and research grant activity, advanced materials is a strong technology thread across industry and universities in Massachusetts. It speaks directly to Massachusetts' long history in plastics, precision machining and textiles, and relates to the state's future as a center for innovative products and emerging industries, from fuel cells to nanoelectronics to adaptive materials (i.e., having properties to monitor health signs, adapt to weather changes, etc.).

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Electronics, medical devices, metalworking, paper converting, plastics, textiles and apparel**

EXAMPLES OF INDUSTRY LEADERS:

**Cabot Corporation**  
**General Electric**  
**Gillette**  
**Spalding Sports**  
**Nypro**  
**Saint-Gobain**

UNIVERSITY LEADERS:

**Harvard**  
**M.I.T.**  
**Northeastern**  
**Tufts**  
**UMass Amherst**  
**UMass Lowell**  
**WPI**

#### KEY INDUSTRY CLUSTERS:

Electronics  
 Medical devices  
 Metalworking  
 Paper converting  
 Plastics  
 Textiles and apparel

#### EXAMPLES OF TECHNOLOGY ACTIVITIES:

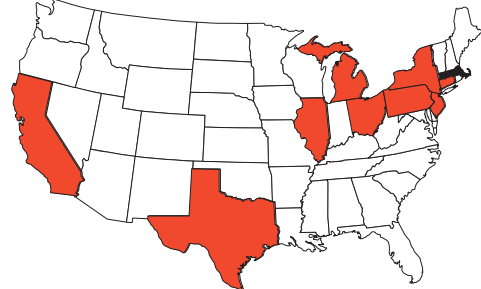
Coatings and multi-layer depositions  
 Carbon nanotubes  
 Biomaterials  
 Advanced alloys  
 Near net-shape light metals  
 Coatings and multi-layer depositions  
 Polymer synthesis  
 Processing polymers at nanoscale  
 Novel material properties for fibers

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Illinois, Massachusetts, Michigan, New York, Ohio, Pennsylvania, Texas**

#### Technology Industry Presence

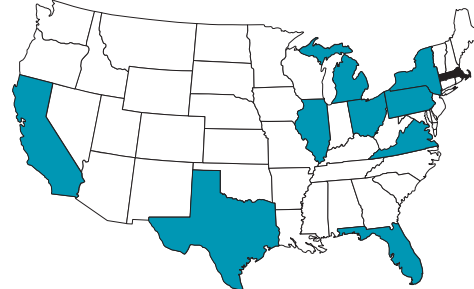
Top ten states in number of technology firms, 2003



1. California
2. Ohio
3. Pennsylvania
4. New Jersey
5. Texas
6. **Massachusetts**
7. Illinois
8. New York
9. Michigan
10. Connecticut

#### Talent Generation

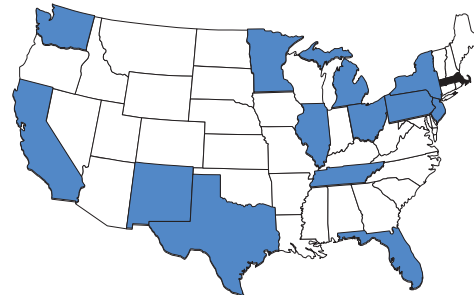
Top ten states in total degrees awarded, 2002



1. California
2. Michigan
3. New York
4. Pennsylvania
5. Ohio
6. Texas
7. **Massachusetts**
8. Illinois
9. Virginia
10. Florida

#### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- California
- Florida
- Illinois
- Massachusetts
- Michigan
- Minnesota
- New Jersey
- New Mexico
- New York
- Ohio
- Pennsylvania
- Tennessee
- Texas
- Washington

# SIGNAL PROCESSING

**WHAT IS IT?** Signal processing is a foundation technology for communications, computing and embedded systems found in devices. It involves a wide range of activities for transmitting, processing and analyzing signals from audio, video, image, and radar, among other signals.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** In Massachusetts, signal processing is a major technology focus of industry, and has a strong concentration in patent activities. Its roots began in the defense industry in advancing the use of radar in World War II, which Massachusetts pioneered, through tracking systems for ballistic missiles during the Cold War to today's information-based warfare activities. Today, signal processing technologies extend extensively into the computer and telecommunications sector. Signal processing also remains a key expertise of major federal defense-related research centers and organizations from Lincoln Labs to Draper Labs to MITRE Corporation.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Defense industries, telecommunications, computer hardware/electronic systems, power systems**

EXAMPLES OF INDUSTRY LEADERS:

**Analog Devices**

**Raytheon**

**Teradyne**

**EMC**

**Verizon**

UNIVERSITY LEADERS:

**M.I.T.**

**Boston University**

**UMass Amherst**

**Harvard**

**WPI**

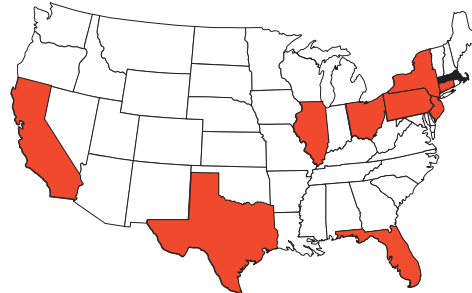
KEY INDUSTRY CLUSTERS:	EXAMPLES OF TECHNOLOGY ACTIVITIES:
Defense industries	RF technologies Micro-wave technologies
Telecommunications	Wireless communications Digital-analog switching
Computer hardware/ Electronic systems	Digital signal transmission, Amplification, Switching, Embedded network systems
Power systems	Voltage/power transmitters, Switching

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Florida, Illinois, Massachusetts, New York, Ohio, Pennsylvania, Texas**

### Technology Industry Presence

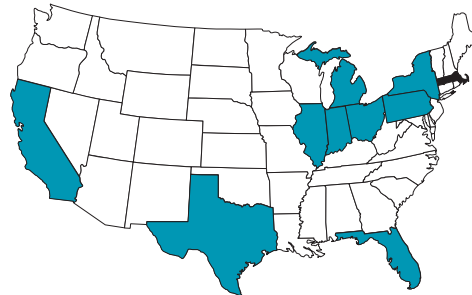
Top ten states in number of technology firms, 2003



1. California
2. **Massachusetts**
3. New York
4. New Jersey
5. Texas
6. Pennsylvania
7. Florida
8. Illinois
9. Connecticut
10. Ohio

### Talent Generation

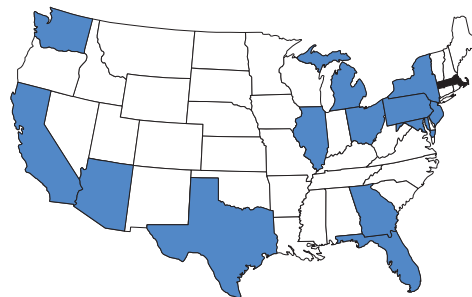
Top ten states in total degrees awarded, 2002



1. California
2. New York
3. Texas
4. Pennsylvania
5. Florida
6. Ohio
7. Illinois
8. Michigan
9. **Massachusetts**
10. Indiana

### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- Arizona
- California
- Florida
- Georgia
- Illinois
- Maryland
- Massachusetts
- Michigan
- New Jersey
- New York
- Ohio
- Pennsylvania
- Texas
- Washington

# COMPUTER SCIENCES

**WHAT IS IT?** Computer sciences remains a dynamic, fast-paced technology field involving all aspects of computing from software development to databases to information analysis and retrieval to networking to decision-making and data visualization. Computer sciences is at the intersection of many converging technologies, particularly key for collecting, managing, and interpreting the massive sets of data possible today in fields from genomics and proteomics to supply chain management to financial services.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** Computer sciences is firmly rooted in the economic landscape of Massachusetts' technology industry base. As the patent data suggests, there are literally hundreds of firms developing key applications and new computer-related technologies. Massachusetts is also home to a number of leading university computer science research programs found at M.I.T., UMass Amherst, Harvard and Boston University, and is home to many federal research centers and labs focusing on computer science related activities.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

- Computer services**
- Defense industries**
- Health care**
- Financial services**

EXAMPLES OF INDUSTRY LEADERS:

- Avid Technology**
- Cognex**
- EMC**
- Raytheon**
- Verizon**

UNIVERSITY LEADERS:

- M.I.T.**
- UMass Amherst**
- Harvard**
- Boston University**

### KEY INDUSTRY CLUSTERS:

- Computer services
- Defense industries
- Health care
- Financial services

### EXAMPLES OF TECHNOLOGY ACTIVITIES:

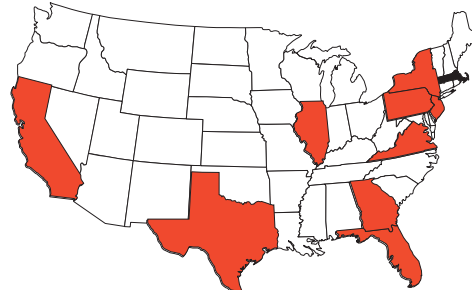
- Data storage
- Computer modeling and simulation
- Distributed systems
- Computer security
- Computer networking
- Data mining and information retrieval
- Software applications development

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Illinois, Massachusetts, Pennsylvania, Texas**

### Technology Industry Presence

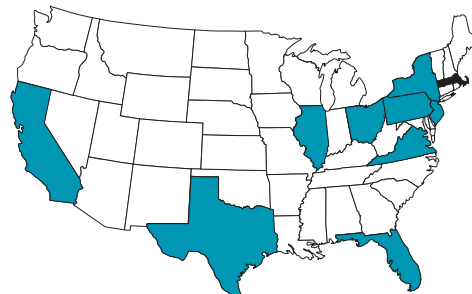
Top ten states in number of technology firms, 2003



1. California
2. **Massachusetts**
3. Texas
4. New York
5. Pennsylvania
6. Florida
7. Illinois
8. Virginia
9. New Jersey
10. Georgia

### Talent Generation

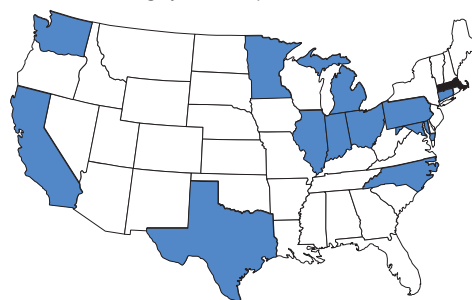
Top ten states in total degrees awarded, 2002



1. New York
2. California
3. Pennsylvania
4. Texas
5. Florida
6. Illinois
7. Ohio
8. **Massachusetts**
9. New Jersey
10. Virginia

### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- California
- Connecticut
- Illinois
- Indiana
- Maryland
- Massachusetts
- Michigan
- Minnesota
- North Carolina
- Ohio
- Pennsylvania
- Texas
- Washington

# SENSING, OPTICAL AND ELECTRO-MECHANICAL DEVICES

**WHAT IS IT?** Central to high-tech manufacturing for advanced instruments, machinery and components are a broad set of technologies that enable measuring, sensing, actuation and the fusion of electrical and mechanical systems in ever more miniaturized components.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** Massachusetts has a long tradition in precision equipment machining, dating back to the 1800's and evolving over several technology transitions into manufacturing of complex industrial products including computers, telecommunications exchanges and switches, electricity transformers, chip-making machines, electro-medical devices and air traffic control systems. The technology area of sensing, optical and electro-mechanical devices is one of the largest clustering of patents found in Massachusetts, led by industry activity. At the university level, Massachusetts is at the cutting edge of many sensing and optical technologies, as well as an emerging leader in micro-electro-mechanical devices (MEMS) and nanotechnology fabrication.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Industrial machinery, computer and communications equipment, medical devices, defense industries**

EXAMPLES OF INDUSTRY LEADERS:

**Analog Devices  
Boston Scientific  
Osram Sylvania  
Raytheon  
Thermo Electron**

UNIVERSITY LEADERS:

**M.I.T.  
Harvard  
Northeastern  
UMass Amherst  
Tufts**

#### KEY INDUSTRY CLUSTERS:

Industrial machinery  
  
Computer and communications equipment  
  
Medical devices  
  
Defense industries

#### EXAMPLES OF TECHNOLOGY ACTIVITIES:

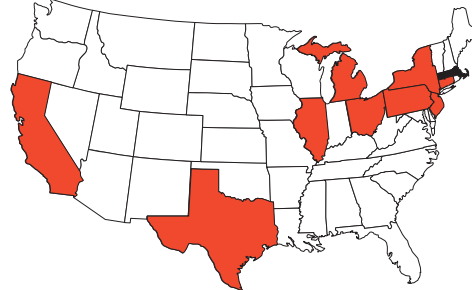
Laser devices  
Sensors and actuators  
Gas and liquid flow systems  
  
MEMS devices  
  
Sensors and imaging devices  
Radar systems

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Illinois, Massachusetts, Michigan, Ohio, Pennsylvania**

#### Technology Industry Presence

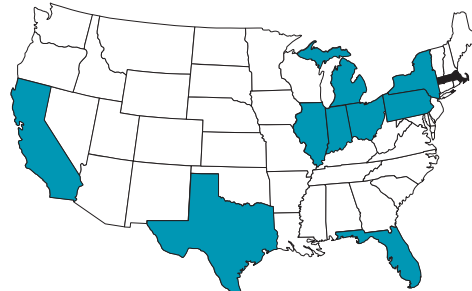
Top ten states in number of technology firms, 2003



1. California
2. Pennsylvania
3. **Massachusetts**
4. New York
5. Illinois
6. Texas
7. Ohio
8. New Jersey
9. Connecticut
10. Michigan

#### Talent Generation

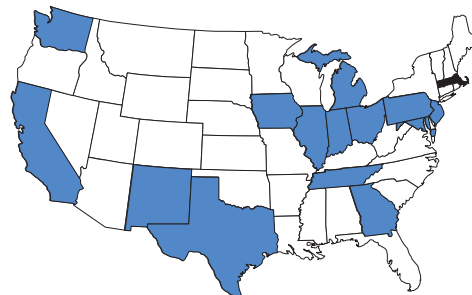
Top ten states in total degrees awarded, 2002



1. California
2. New York
3. Texas
4. Michigan
5. Pennsylvania
6. Ohio
7. Illinois
8. **Massachusetts**
9. Florida
10. Indiana

#### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- California
- Georgia
- Illinois
- Indiana
- Iowa
- Maryland
- Massachusetts
- Michigan
- New Jersey
- New Mexico
- Ohio
- Pennsylvania
- Tennessee
- Texas
- Washington

# ENVIRONMENTAL SCIENCES

**WHAT IS IT?** Environmental sciences involve understanding the basic physical and biological processes occurring in marine life and oceanography, ecosystems, climate and earth sciences. Its practical applications range from developing new technologies for detecting and monitoring changes in environmental systems to abating or preventing pollution or generation of toxic chemicals to protecting coastal areas to harnessing the potential of environmental processes for creating new sustainable products.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** Environmental sciences represent a critical mass of research activity found across university research drivers and non-profit research institutions in Massachusetts, with a particular emphasis on ocean environmental sciences and climate change. While there is not a cluster of industry-led patent activity found in environmental sciences, there is a growing environmental industry presence. Connecting this emerging environmental industry with the growing base of academic research activities in the environmental sciences can provide a competitive advantage.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Environmental engineering and protection, oceanographic industry, fisheries**

EXAMPLES OF INDUSTRY LEADERS:

**BOC Edwards**  
**CDM**  
**Clean Harbors Environmental Services**  
**Thermo Electron**

UNIVERSITY LEADERS:

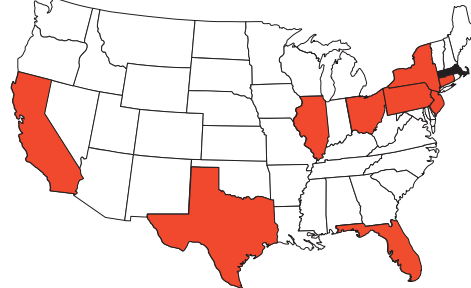
**M.I.T.**  
**Woods Hole**  
**Harvard**  
**UMass Amherst**  
**Boston University**

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Illinois, Massachusetts, New York, Texas**

#### Technology Industry Presence

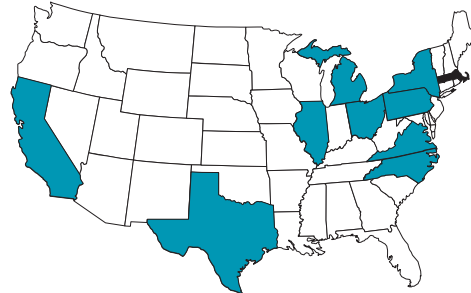
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#### Talent Generation

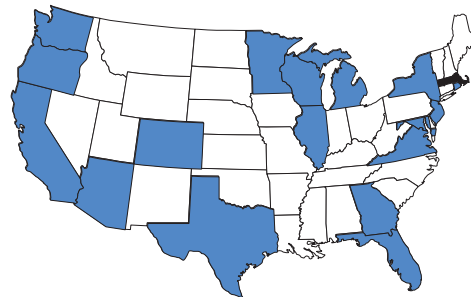
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9. Michigan
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- Arizona
- California
- Colorado
- Florida
- Georgia
- Illinois
- Maryland
- Massachusetts
- Michigan
- Minnesota
- New Jersey
- New York
- Oregon
- Rhode Island
- Texas
- Virginia
- Washington
- Wisconsin

KEY INDUSTRY CLUSTERS:	EXAMPLES OF TECHNOLOGY ACTIVITIES:
Environmental engineering and protection	Water quality research Green chemistry
Oceanographic industry (often with strong defense connections for naval activities and increasingly homeland security applications)	Integrated sensing and information systems
Fisheries	Oceanographic and marine science research



# GENOMICS AND PROTEOMICS

**WHAT IS IT?** Genomics and proteomics involves understanding the structure and function of genes and proteins, holding the potential to identify major new therapeutic approaches to treating diseases. This advanced field of biotechnology represents an area of technology convergence with computational biology and bioinformatics involving the use of advanced, computer-aided modeling, algorithms, pattern discovery, and data mining, visualization and management to infer information about the role of a gene or protein.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** The major position of Massachusetts in biotechnology is based on the broad-based strengths found in genomics and proteomics found across industry, teaching hospitals and university research institutions. Having both a strong presence in patent activity and federal research grant activity allows Massachusetts to be well-positioned to take advantage of this fast-paced, evolving field where there are connections between product development and basic research discoveries.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Electronics, medical devices, metalworking, paper converting, plastics, textiles and apparel**

EXAMPLES OF INDUSTRY LEADERS:

**Genzyme**  
**Millennium Pharmaceuticals**  
**New England Biolabs**  
**Partners HealthCare System**

UNIVERSITY LEADERS:

**Harvard**  
**M.I.T.**  
**UMass Medical Center**  
**Tufts**  
**UMass Amherst**

#### KEY INDUSTRY CLUSTERS:

Biotechnology industry involving broad range of activities from commercial research, diagnostics and new therapeutics development

Pharmaceutical industry

#### EXAMPLES OF TECHNOLOGY ACTIVITIES:

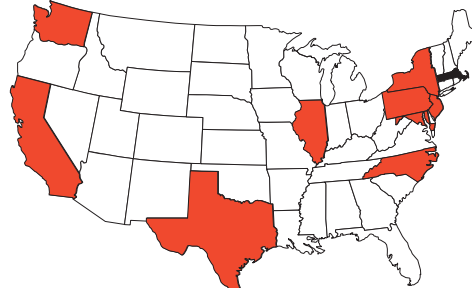
Bioinformatics  
 Gene expression and regulation  
 Gene therapy  
 Micro-array technologies  
 Protein analysis  
 RNA interference (gene silencing)  
 Systems biology

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Massachusetts, New York, North Carolina, Pennsylvania, Texas**

#### Technology Industry Presence

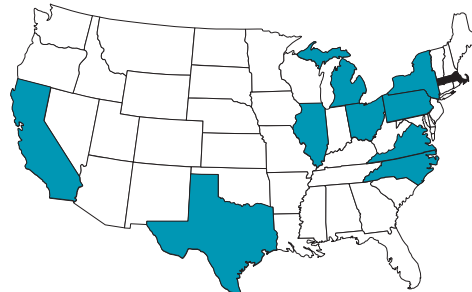
Top ten states in number of technology firms, 2003



1. California
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9. Texas
10. Washington

#### Talent Generation

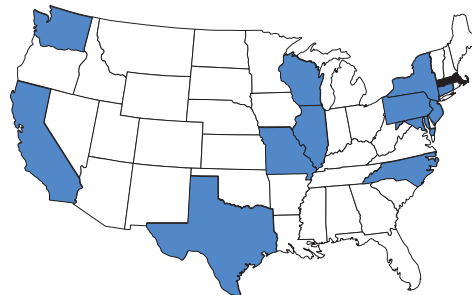
Top ten states in total degrees awarded, 2002



1. California
2. Texas
3. New York
4. Pennsylvania
5. Illinois
6. Ohio
7. **Massachusetts**
8. North Carolina
9. Michigan
10. Virginia

#### Research Excellence

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- California  
 Connecticut  
 Maryland  
 Massachusetts  
 Missouri  
 New Jersey  
 New York  
 North Carolina  
 Pennsylvania  
 Texas  
 Washington  
 Wisconsin

# DISEASE RESEARCH AND DRUG DISCOVERY

**WHAT IS IT?** Advanced disease specific research, applying biotechnology related techniques, can lead to discoveries of highly promising biological targets for developing new drug therapies, from traditional chemical drug agents, vaccines and innovative new biological therapies as well.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** As a leading center for disease-related research, Massachusetts teaching hospitals and university research institutions offer major opportunities for identifying biological targets and discovering potential drug compounds and innovative biological therapies. At the same time, there is a growing base of pharmaceutical and biotechnology companies for translating these drug discoveries into clinical and commercial use.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Pharmaceutical industry**

EXAMPLES OF INDUSTRY LEADERS:

**Millennium Pharmaceuticals**

**Partners HealthCare System**

**Sepracor, Inc.**

**Vertex Pharmaceuticals**

UNIVERSITY LEADERS:

**M.I.T.**

**Harvard**

**Northeastern**

**UMass Amherst**

**Tufts**

### KEY INDUSTRY CLUSTERS:

Pharmaceutical industry  
Biotechnology industry involved in new therapeutics development

### EXAMPLES OF TECHNOLOGY ACTIVITIES:

Cluster activities in disease research found in:  
Cancer research, Cardiovascular research, Infectious diseases, HIV Neurosciences

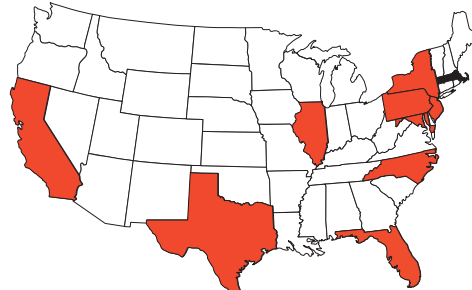
Patent activity in drug discovery and development involving:  
Tumor suppressors, Neurological drug agents, Anti-infectious drug agents, Drug delivery

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Massachusetts, New York, North Carolina, Pennsylvania, Texas**

### Technology Industry Presence

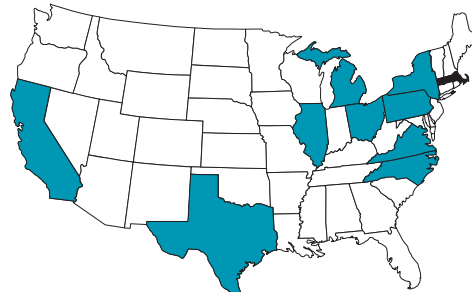
Top ten states in number of technology firms, 2003



1. California
2. New Jersey
3. **Massachusetts**
4. Pennsylvania
5. New York
6. North Carolina
7. Texas
8. Maryland
9. Illinois
10. Florida

### Talent Generation

Top ten states in total degrees awarded, 2002



1. California
2. New York
3. Texas
4. Pennsylvania
5. Illinois
6. **Massachusetts**
7. North Carolina
8. Ohio
9. Michigan
10. Virginia

### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- California
- Connecticut
- Maryland
- Massachusetts
- Michigan
- Missouri
- New York
- North Carolina
- Pennsylvania
- Texas
- Washington
- Wisconsin

# BIOMEDICAL DEVICES

**WHAT IS IT?** Biomedical device technologies involve the convergence of biological processes with materials, electronics and software. The emerging field of biomedical devices is playing into the established and growing health care industry offering major new capabilities from non-invasive techniques to advanced implants and regenerative approaches to new drug delivery approaches.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** Massachusetts has a growing base of formal and informal research programs found across university and teaching hospitals that can infuse new technologies into biomedical devices and help position the existing biomedical device industry in Massachusetts for growth.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Biomedical devices**

EXAMPLES OF INDUSTRY LEADERS:

**ABIOMED**

**C.R. Bard**

**Boston Scientific**

**Codman and Shurtleff, Inc.**

**Cytc**

**Genzyme Corporation**

**Partners HealthCare System**

**Phillips Medical Systems**

**Smith & Nephew**

UNIVERSITY LEADERS:

**M.I.T.**

**Boston University**

**WPI Bioengineering Institute**

#### KEY INDUSTRY CLUSTERS:

Biomedical devices

#### EXAMPLES OF TECHNOLOGY ACTIVITIES:

Bioprocessing

Imaging

Non-invasive technologies

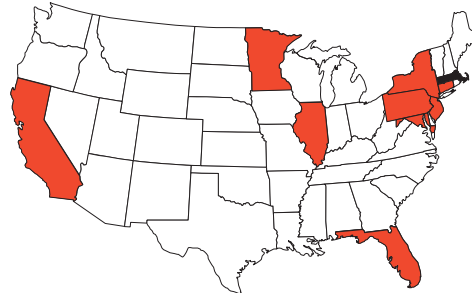
Tissue engineering

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Massachusetts, Pennsylvania**

#### Technology Industry Presence

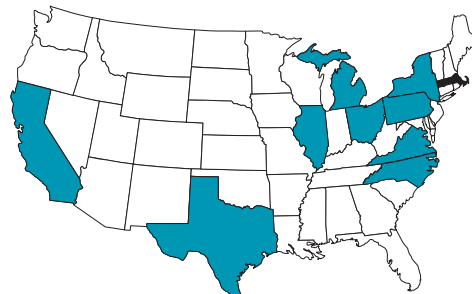
Top ten states in number of technology firms, 2003



1. California
2. **Massachusetts**
3. New Jersey
4. New York
5. Pennsylvania
6. Minnesota
7. Florida
8. Maryland
9. Illinois
10. Connecticut

#### Talent Generation

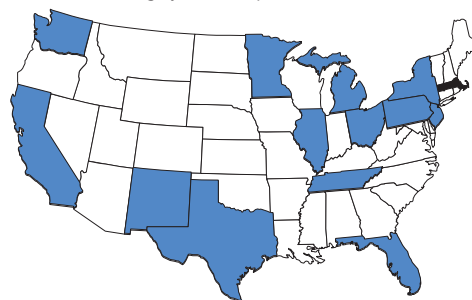
Top ten states in total degrees awarded, 2002



1. California
2. Texas
3. New York
4. Pennsylvania
5. Michigan
6. Illinois
7. Ohio
8. **Massachusetts**
9. Virginia
10. North Carolina

#### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- California
- Georgia
- Maryland
- Massachusetts
- Michigan
- Missouri
- North Carolina
- Ohio
- Pennsylvania
- Texas
- Washington

# RENEWABLE ENERGY

**WHAT IS IT?** Renewable energy is involved in developing advanced technologies for harnessing alternative energy generating processes found in chemical reactions, solar power and wind power which do not rely on non-renewable natural resources nor degrade the environment. It draws upon cross-cutting technology areas from polymer research to green chemistry to microbiology.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** Renewable energy is an emerging field of technology applications in Massachusetts with a growing base of industry activities and many niche areas of research focus such as biobatteries converting organic waste matter to energy and the use of polymer processing for developing solar power

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

KEY INDUSTRY CLUSTERS:

**Alternative energy generation**

EXAMPLES OF INDUSTRY LEADERS:

**Fuel cell-related companies:** Ballard, Acumentrics, Nuvera, ElectroChem, ZTEK, Dais-Analytic

**Solar power companies:** Evergreen Solar, Konarka Technologies, RWE Schott Solar

**Wind power companies:** SecondWind, Cape Wind Associates

UNIVERSITY LEADERS:

**M.I.T.**

**UMass Amherst**

**UMass Boston**

**WPI**

#### KEY INDUSTRY CLUSTERS:

Alternative energy generation companies

#### EXAMPLES OF TECHNOLOGY ACTIVITIES:

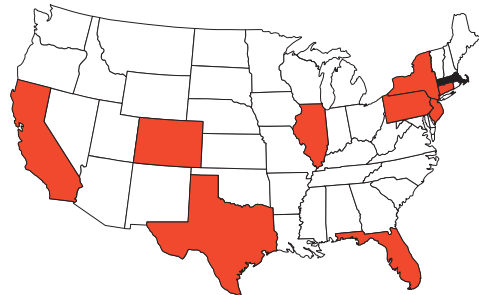
Photovoltaic  
Biobatteries  
Wind power  
Fuel cells

**LEADING STATES** (states ranked highest in all 3 categories researched for the study: Industry Presence, Talent Generation, and Research Excellence)

**California, Illinois, Massachusetts, New York, Pennsylvania, Texas**

#### Technology Industry Presence

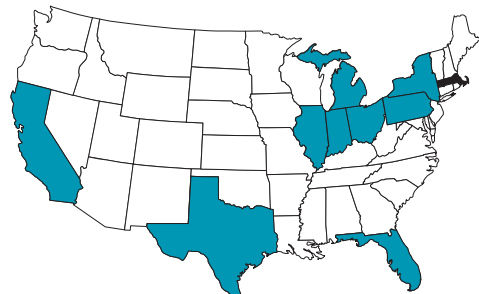
Top ten states in number of technology firms, 2003



1. Texas
2. California
3. **Massachusetts**
4. New York
5. Pennsylvania
6. Colorado
7. Connecticut
8. New Jersey
9. Florida
10. Illinois

#### Talent Generation

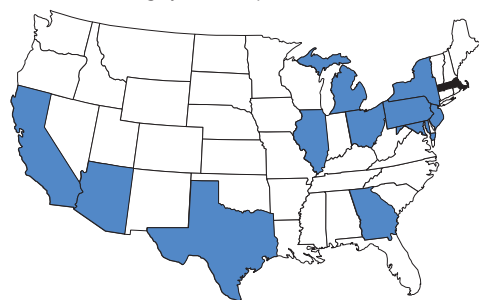
Top ten states in total degrees awarded, 2002



1. California
2. New York
3. Texas
4. Pennsylvania
5. Michigan
6. Ohio
7. Illinois
8. **Massachusetts**
9. Florida
10. Indiana

#### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



- Arizona
- California
- Georgia
- Illinois
- Maryland
- Massachusetts
- Michigan
- New Jersey
- New York
- Ohio
- Pennsylvania
- Texas

# NANOTECHNOLOGY FABRICATION

**WHAT IS IT?** Nanotechnology fabrication involves developing new structures based on the precise control of materials architecture at the molecular or atomic level. Nanofabrication has been heralded as a revolutionary advance in manufacturing a next generation of products offering unique properties and decreasing time to market, energy consumption and environmental costs. In particular, nanotechnology addresses the need to scale down the size of chips, the basic building block of our IT-driven economy.

**WHAT DOES IT MEAN FOR MASSACHUSETTS?** The prospects of nanotechnology to redefine the leading-edge of future manufacturing is real and Massachusetts with its history of precision machining and complex products development has an opportunity to be a leading center for nanofabrication, based on the growing strength of its university research programs. Translating those research competencies in the future into industry competencies will require a focused program of collaboration and strategic alliances.

## LEAD PLAYERS

### MASSACHUSETTS' LEADERS

#### UNIVERSITY RESEARCH PROGRAMS:

Many universities in Massachusetts are doing work in nanofabrication—with Harvard, UMass Amherst and M.I.T. among the leading university recipients of nanotechnology research funding—with a particular focus on nanoelectronics, including:

**Harvard's Nanoscale Science and Engineering Center in partnership with M.I.T.** is a major NSF nanotechnology-funded research center.

**UMass Amherst**, is advancing the use of polymer templates for nanofabrication to create the pattern of a device's structure, and recently launched the MassNanoTech Center.

**M.I.T.** has a number of leading nanotechnology research centers including the Nanostructures Laboratory, Soldier Nanotechnologies Center and NanoMechanical Technology Lab.

**Northeastern** leads an NSF-supported Industry-University Cooperative Research Center focused on contamination and fabrication.

**UMass Lowell** Institute on Nanoscience and Engineering Technology.

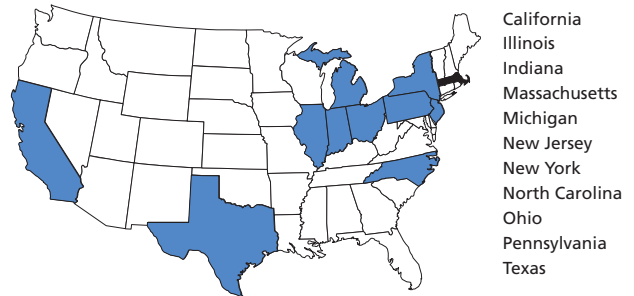
**Boston University** is focusing on bionanotechnology and has a number of research grants in that area.

**RESEARCH EXCELLENCE** (states receiving highest level of National Nanotechnology Institute awards from the National Science foundation, FY 2001 to FY 2003)

**California, Illinois, Indiana, Massachusetts, Michigan, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Texas**

#### Research Excellence

States mentioned either by leading institution (Top Ten) or U.S. News reputation and NSF funding by state in alphabetical order



KEY INDUSTRY CLUSTERS:	EXAMPLES OF TECHNOLOGY ACTIVITIES:
Advanced materials	Polymer templating for nanofabrication Nanomagnetics
Computer and communications hardware	Nano contamination Nanoelectronics

Note: Nanotechnology fabrication, as a very early stage technology, lacks sufficient data for analysis of industry presence and talent generation.