Computational Biotechnology

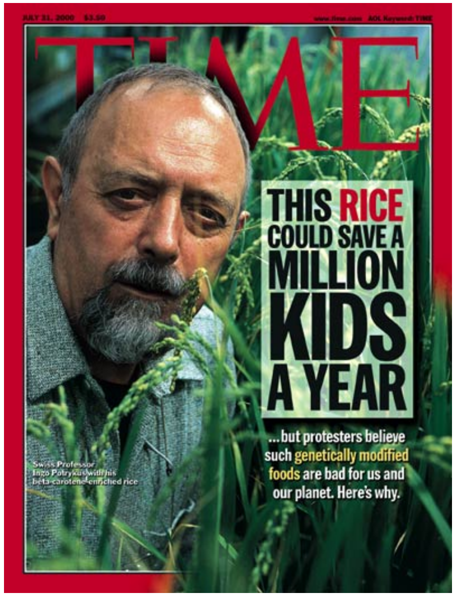
Carlos Óscar Sánchez Sorzano (coss.eps@ceu.es)
Carlos Bocos de Prada (carbocos@ceu.es)

Madrid, February, 1st 2007

Biotechnology is a social/economical current issue

Aug. 2006

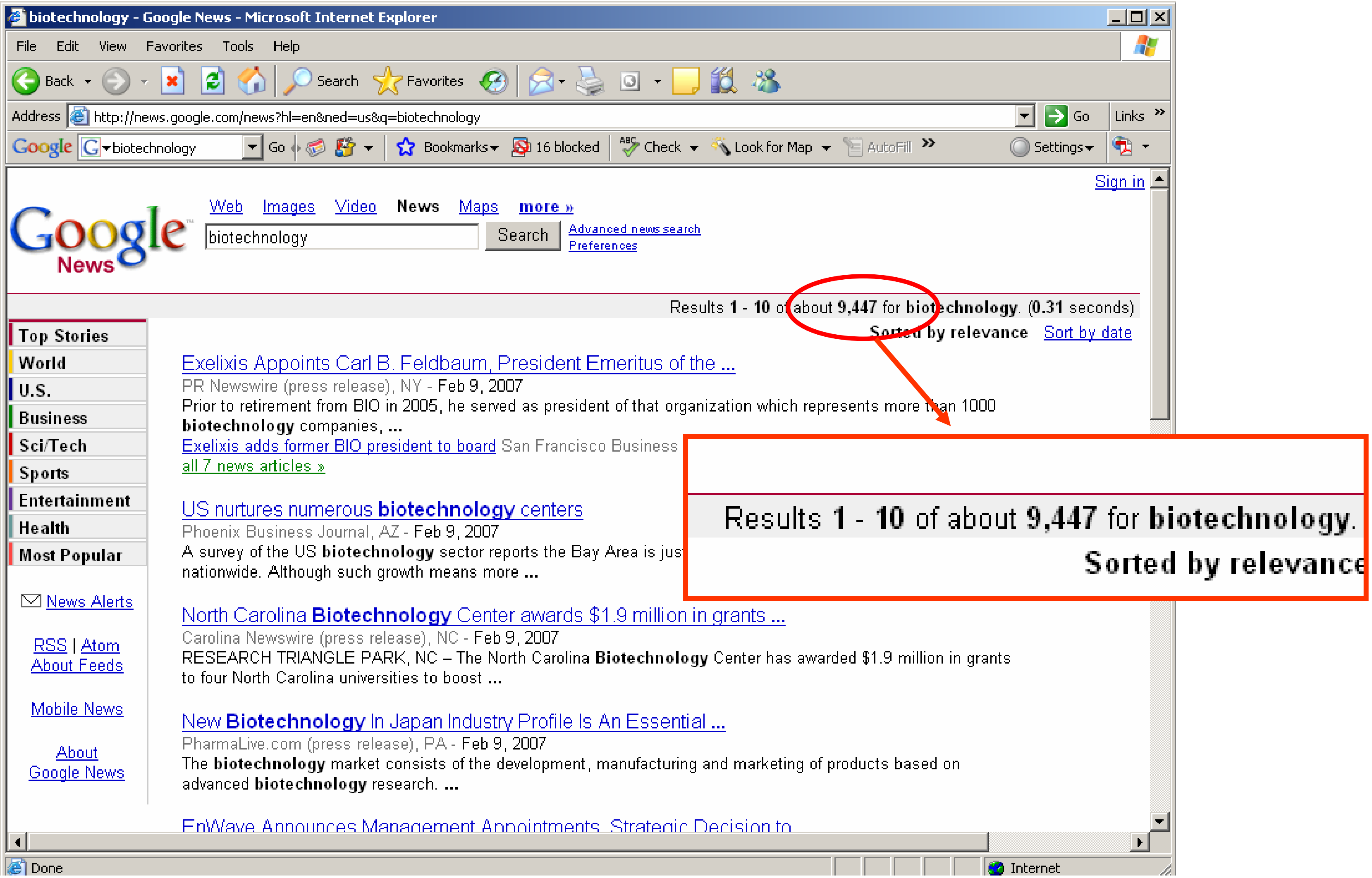
Feb. 2004



July. 2000

Aug. 1998

Biotechnology is a social/economical current issue



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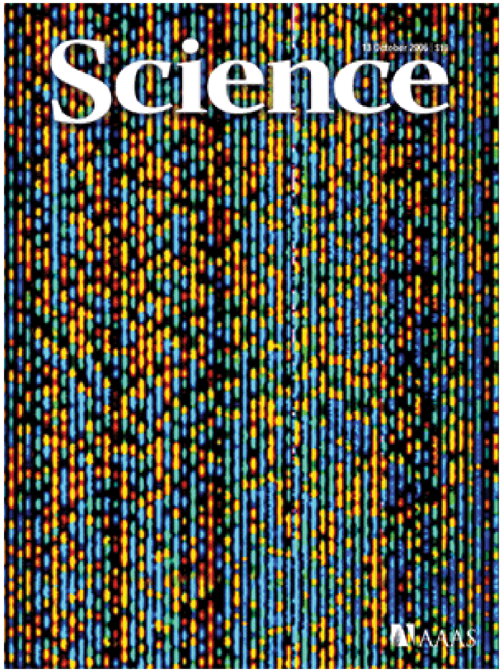
Biotechnology is of primary importance in science



Oct, 2006

Oct, 2006

Sep, 2004

May, 2006

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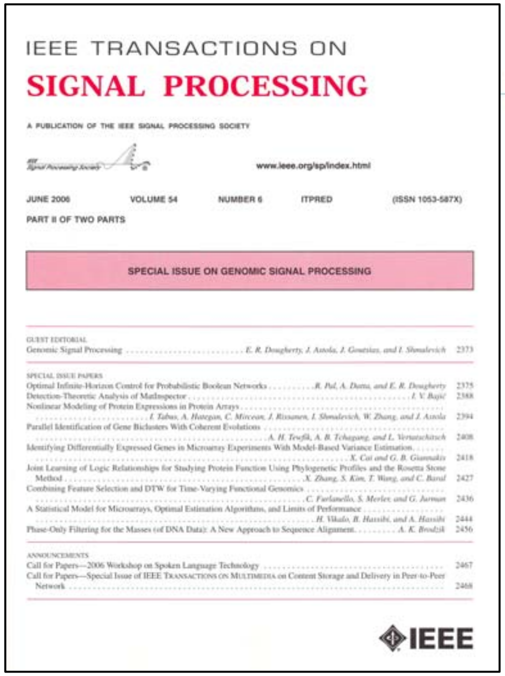
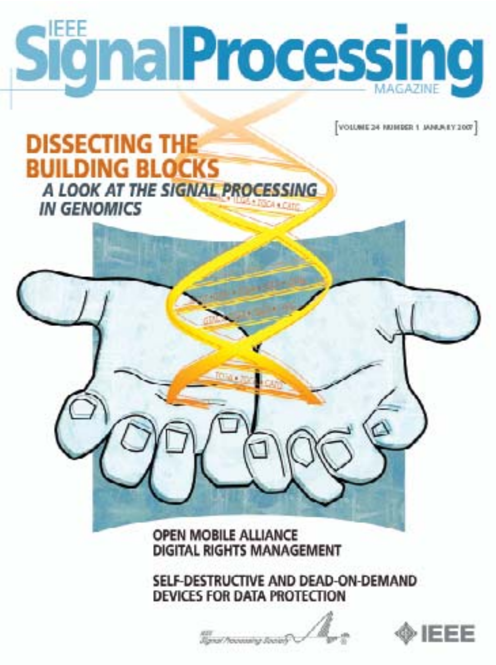
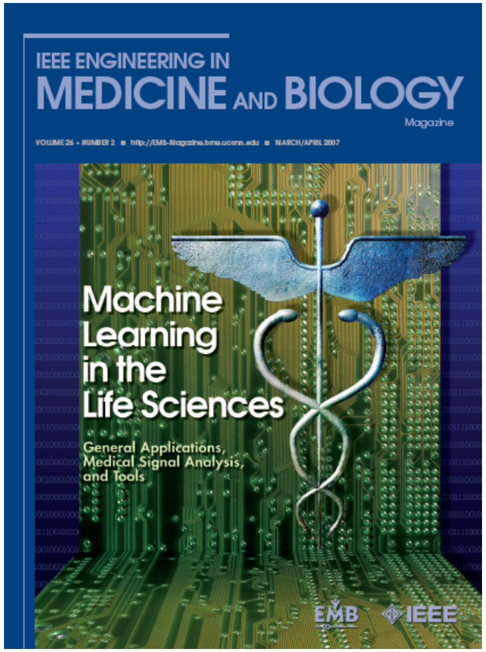
Biotechnology is of primary importance in science



June, 2006

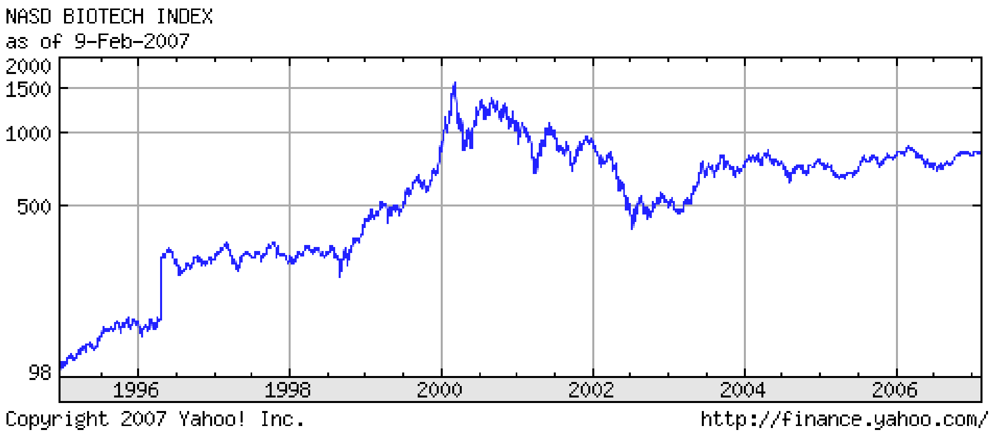


Jan, 2007



Mar, 2007

Biotechnology is a growing and stable industry



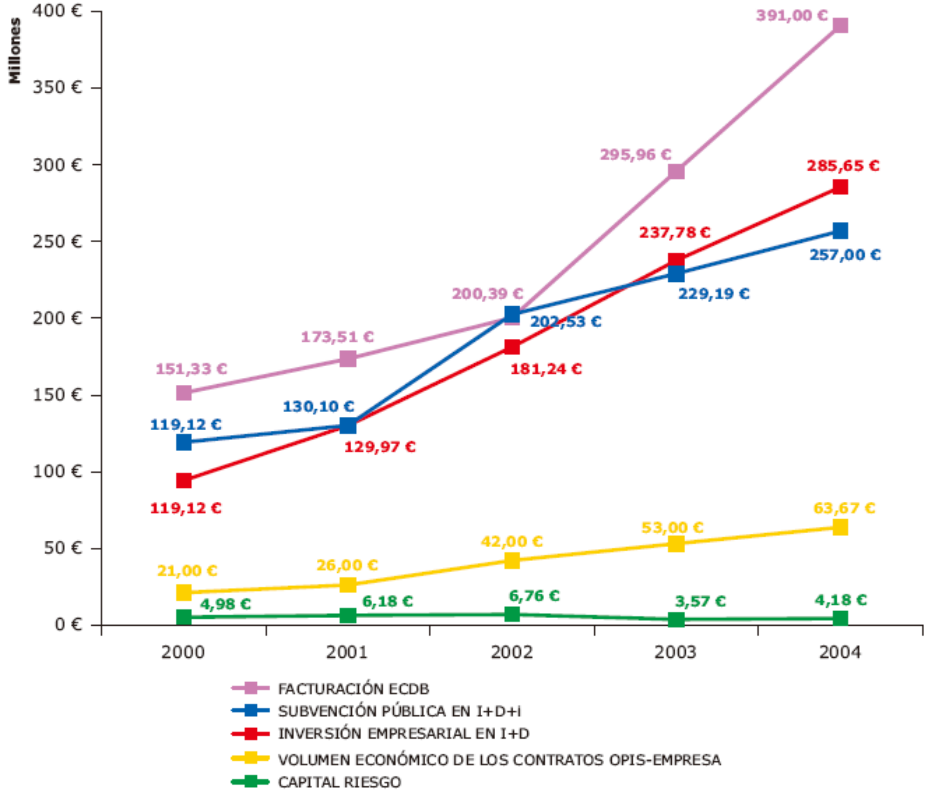
Source: Yahoo finance (2007)

Europe - the typical company

(Financial data in €m)

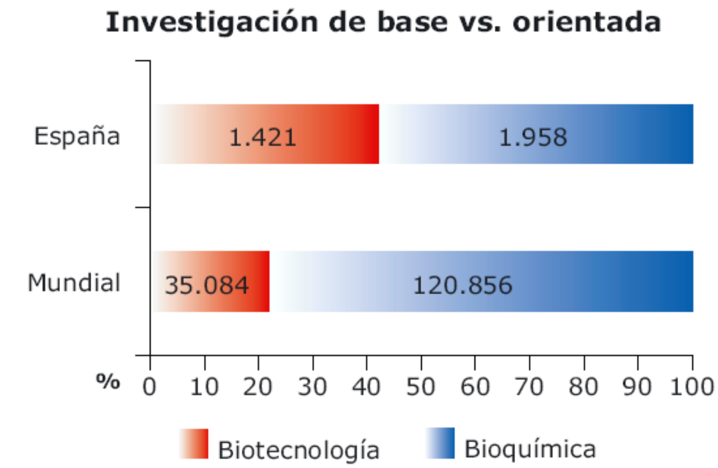
Age (years)	0-2	3-5	6-10	11-15	16+
Employees	9	17	28	41	73
Revenue	€0.34	€1.01	€2.6	€6.07	€19.35
Research strength (personnel)	9	11	17	18	69
Research strength (R&D budget)	€0.69	€1.7	€3.3	€4	€4.69

Source: EuropaBio – Critical I Comparative Study (2006)

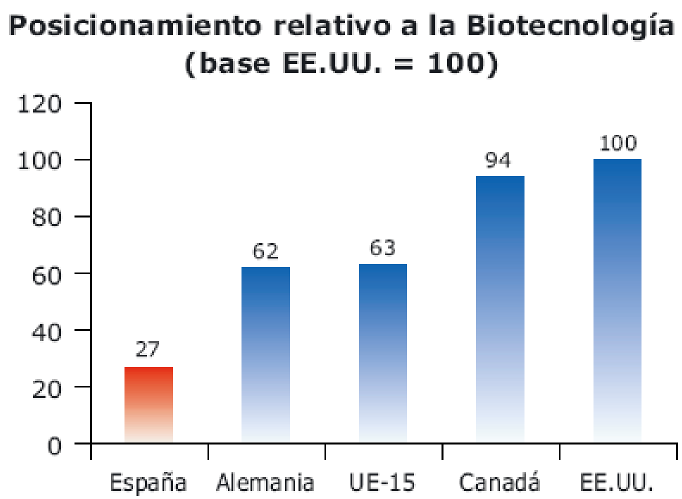


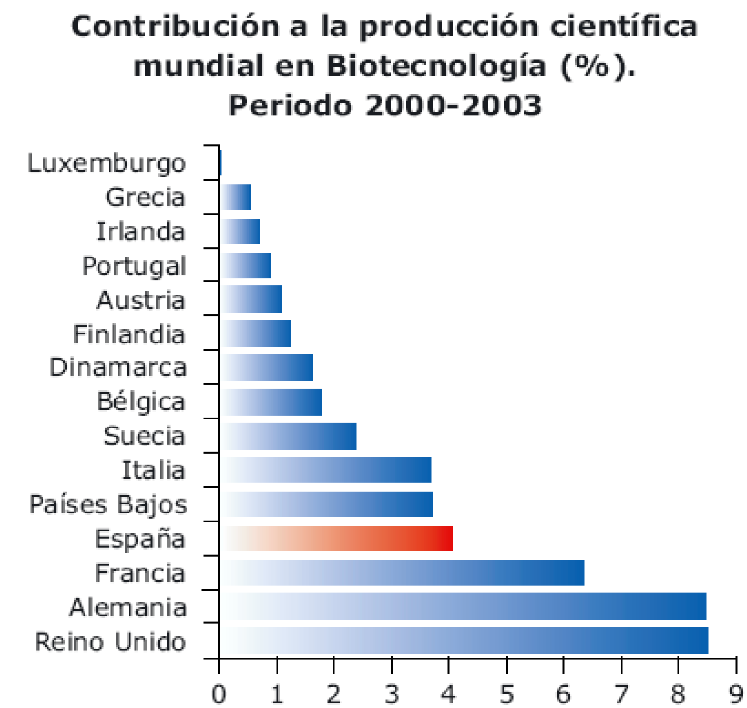
Source: Genoma España - Perspectivas económicas de la Biotecnología en España (2005)

Spain Biotechnology is world competitive



Fuente: CINDOC-CSIC.





Fuente: CINDOC-CSIC.

Source: Genoma España – La biotecnología española (2005)

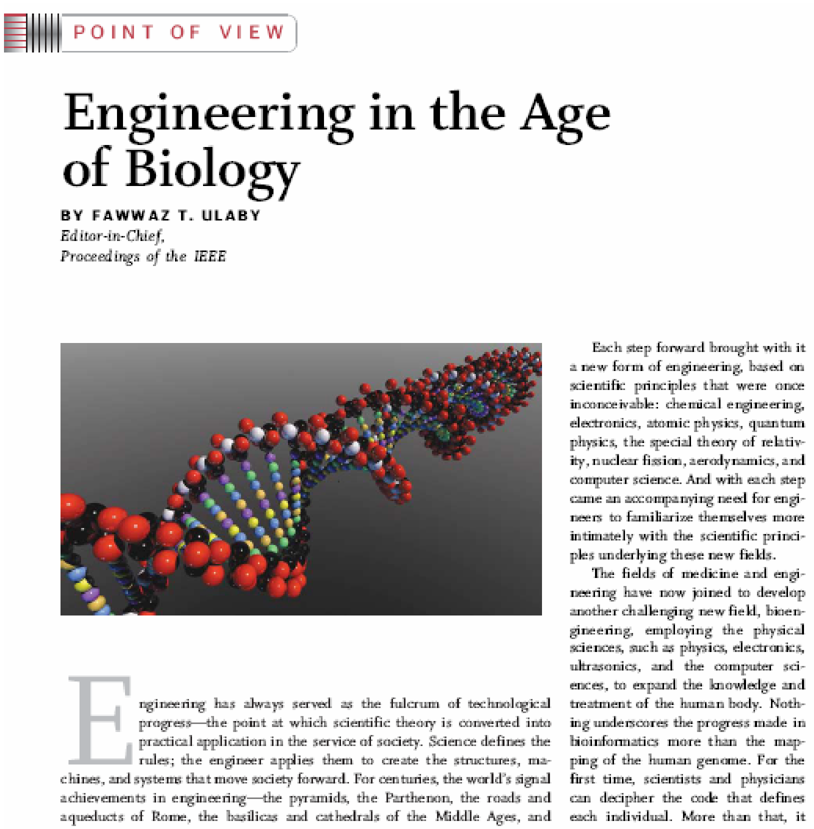
Europe’s Biotechnology policy

Source: http://ec.europa.eu/research/biosociety/policy_aspects/eu_biotech_strategy_en.htm

Life sciences and biotechnology are promising 'frontier' technologies capable of improving our quality of life and fuelling future economic growth. They also raise important ethical and policy challenges requiring coherent European and national strategies.

Europe is poised for a bioscience revolution. Progress in the life sciences and biotechnology is opening the way for groundbreaking discoveries and applications in a wide range of fields, including healthcare, agriculture and environmental protection. These exciting advances are also spawning new scientific disciplines with potentially profound social and economic impacts. Advances in genomics and bioinformatics offer the prospect of even more radical applications, such as personalized medicines and genetic testing leading to preventive health care.

Biotechnology is an expanding field for engineers


POINT OF VIEW

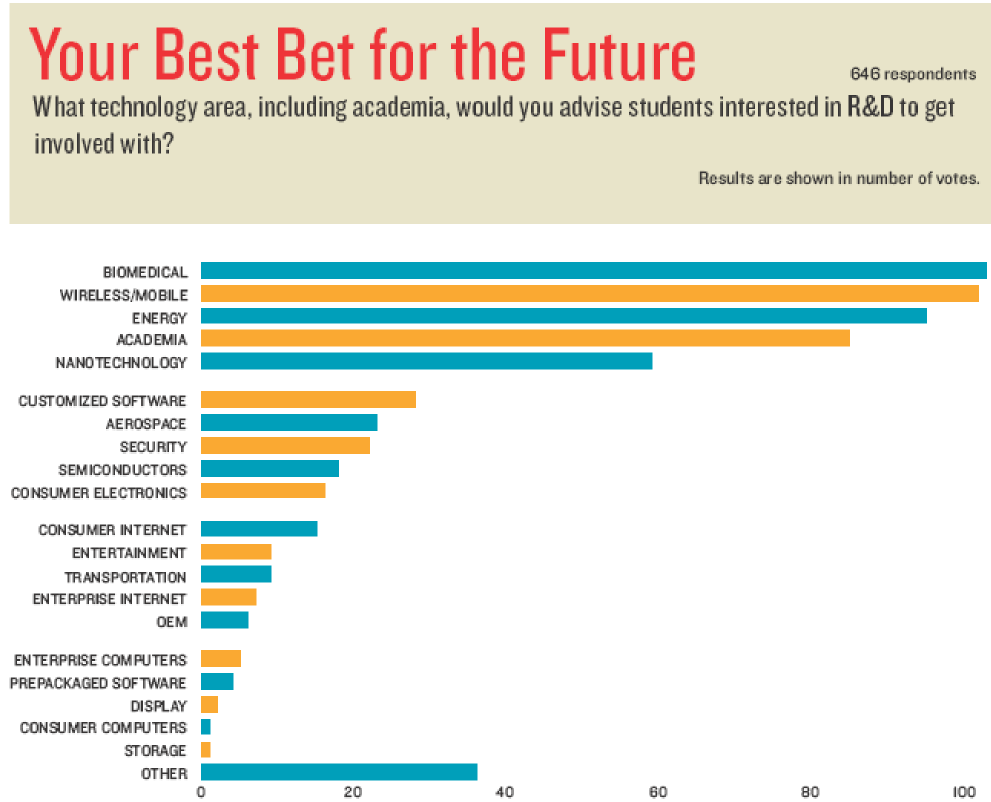
Engineering in the Age of Biology

BY FAWWAZ T. ULABY
Editor-in-Chief, Proceedings of the IEEE

Engineering has always served as the fulcrum of technological progress—the point at which scientific theory is converted into practical application in the service of society. Science defines the rules; the engineer applies them to create the structures, machines, and systems that move society forward. For centuries, the world's signal achievements in engineering—the pyramids, the Parthenon, the roads and aqueducts of Rome, the basilicas and cathedrals of the Middle Ages, and

Each step forward brought with it a new form of engineering, based on scientific principles that were once inconceivable: chemical engineering, electronics, atomic physics, quantum physics, the special theory of relativity, nuclear fission, aerodynamics, and computer science. And with each step came an accompanying need for engineers to familiarize themselves more intimately with the scientific principles underlying these new fields.

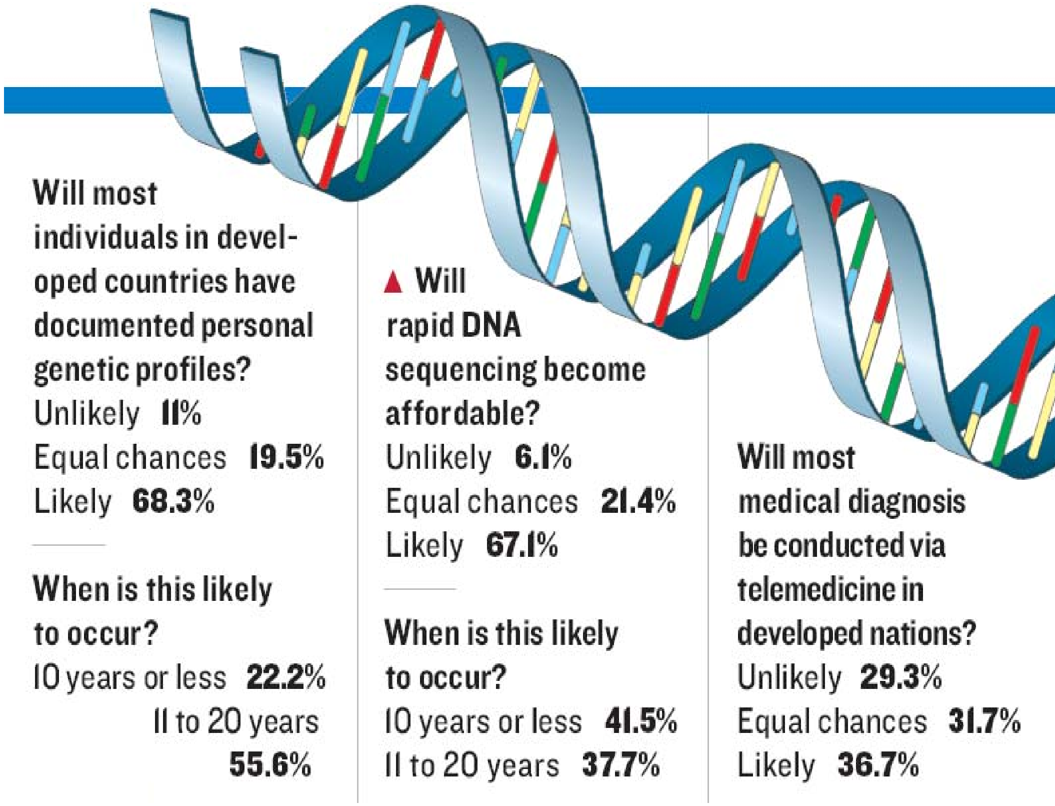
The fields of medicine and engineering have now joined to develop another challenging new field, bioengineering, employing the physical sciences, such as physics, electronics, ultrasonics, and the computer sciences, to expand the knowledge and treatment of the human body. Nothing underscores the progress made in bioinformatics more than the mapping of the human genome. For the first time, scientists and physicians can decipher the code that defines each individual. More than that, it



Fuente: Ulaby. Proc. IEEE, Vol 94: 863-864 (2006)

Fuente: S. Cass. IEEE Spectrum, Vol 44, 2: 45-49 (2007)

Biotechnology is an expanding field for engineers



"The idea of synthetic biology is to do for biology what electrical engineers have done for circuit design and what chemists have done for the synthesis of chemicals—that is, to make an engineering field out of it," says University of California, Berkeley, Professor Jay Keasling, director of Lawrence Berkeley National Laboratory's Synthetic Biology Department. "Rather than just use the natural devices as they exist, we're building new parts that we can integrate into devices that function in predictable ways."

Source:Gorbis, M. & Pescovitz, D. Bursting Tech bubbles before they balloon *IEEE Spectrum*, **2006**, *43*, 50-55

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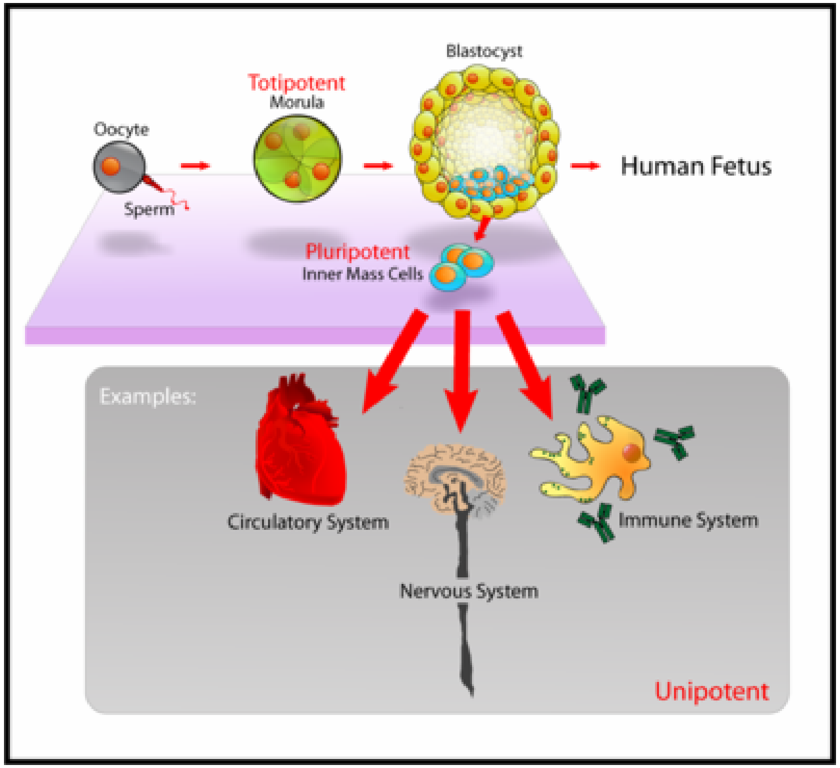
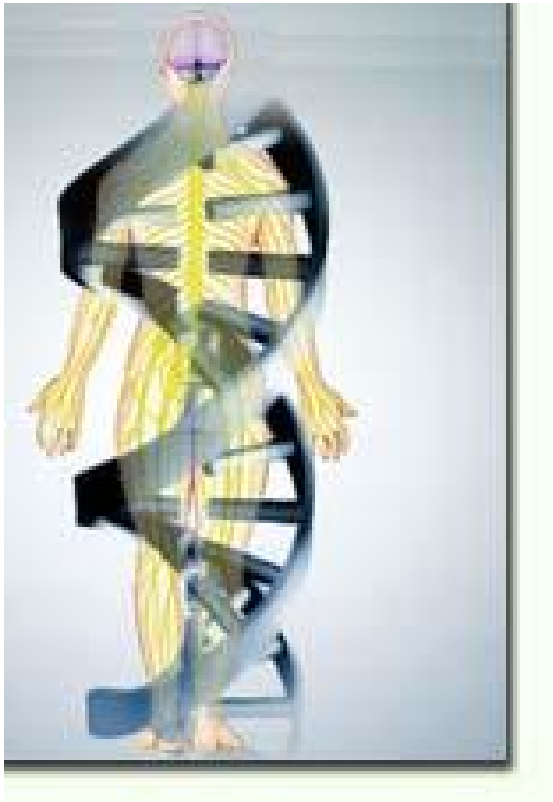
What is Biotechnology about?

Regenerative therapies



Source: http://en.wikipedia.org/wiki/Stem_cell

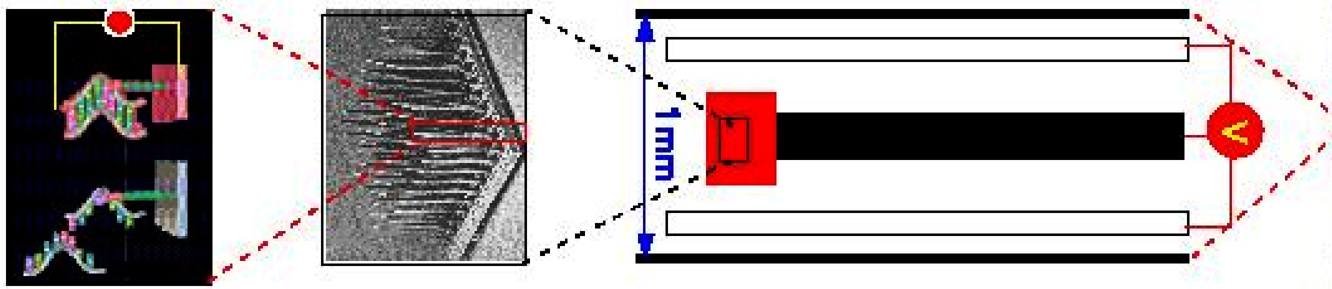
Gene therapies



Source: Avanti Therapeutics
http://www.at-gc.com/doctorDNA.htm

What is Biotechnology about?

Nanotechnology based medicine: Nanosensors



Source: Center for Nanotechnology NASA
http://www.ipt.arc.nasa.gov

Design of new drugs and vaccines

Source: Hauptman-Woodward Medical Research Institute,
http://www.hwi.buffalo.edu/Scientists_Do/Drug_Design.html

Using a program that helps visualize how molecules with different shapes might interact, a scientist tries to fit electronically a potential drug molecule into a cavity in a protein molecule.

What is Biotechnology about?

<u>Vegetal and animal genetic improvements</u>

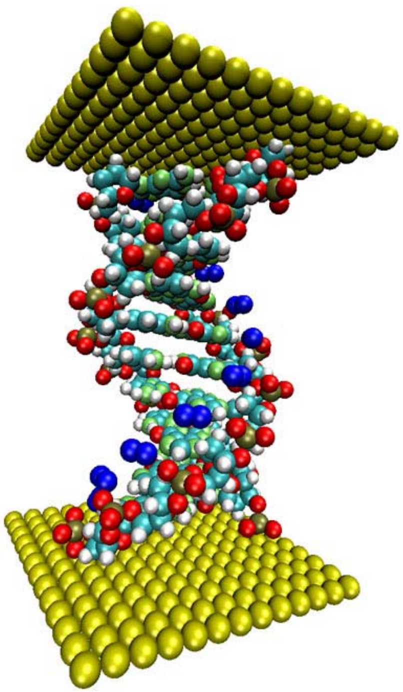
Source: Australian National Measurement Institute
http://www.measurement.gov.au/index.cfm?event=object.showContent&objectID=76B11D8B-BCD6-81AC-1515DD31B83875DE

<u>Food safety and new food products</u>

What is Biotechnology about?

Biomaterials

Source: Center for Nanotechnology NASA
http://www.ipt.arc.nasa.gov



Biofuels

Solution to environmental problems

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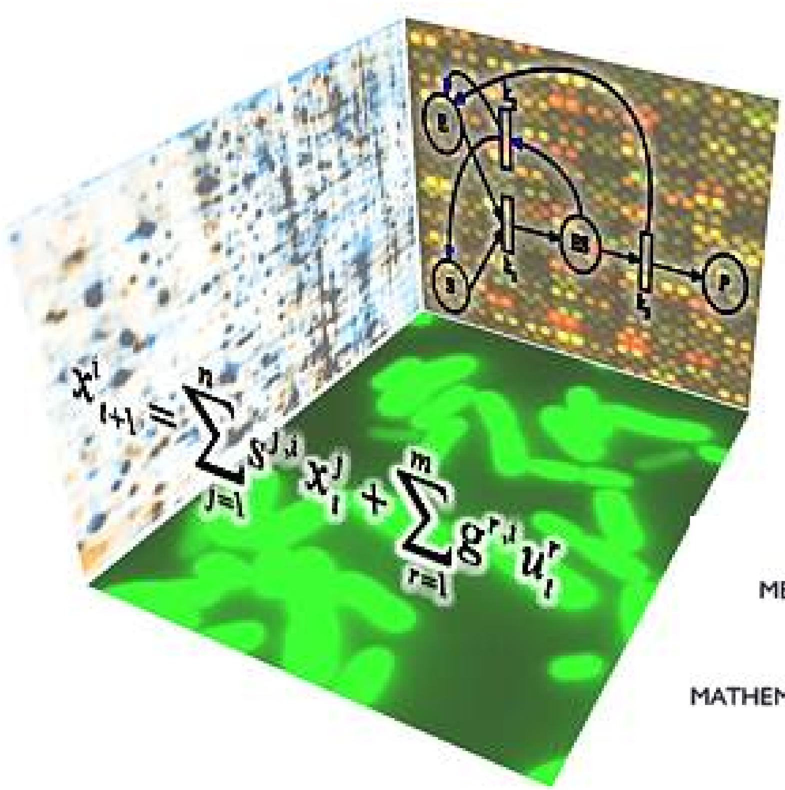
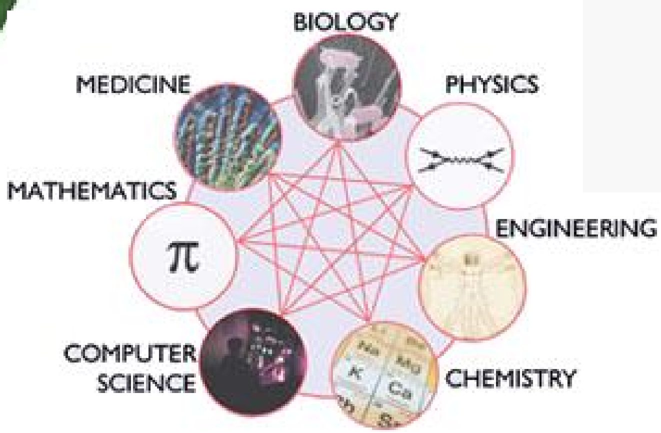
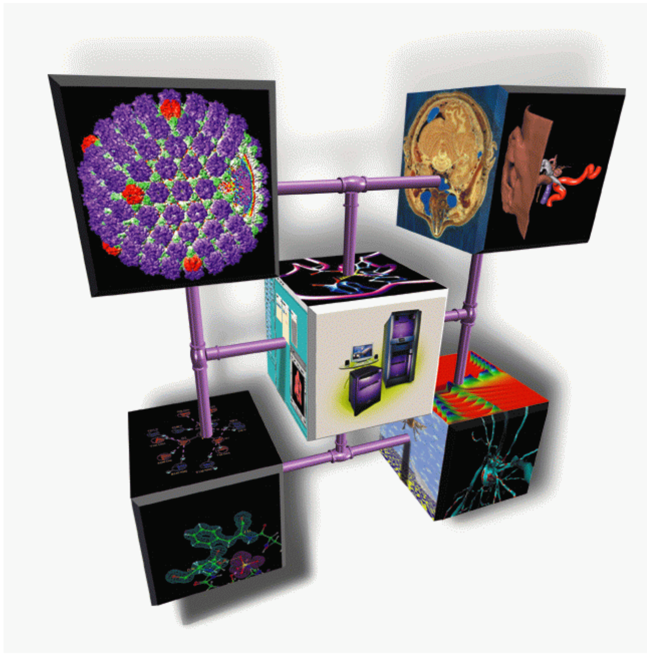
Biotechnology is a multidisciplinary field

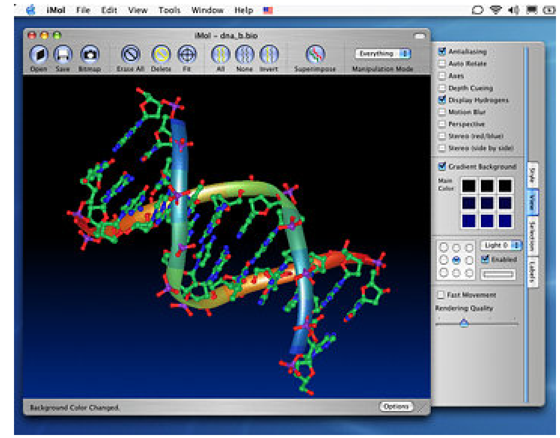


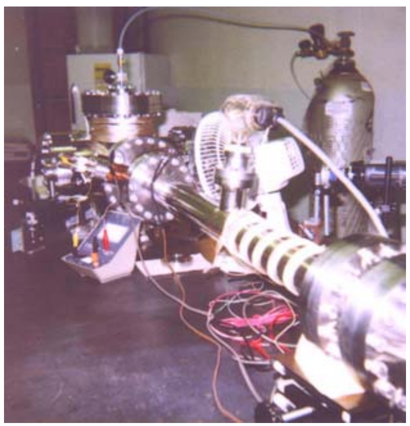


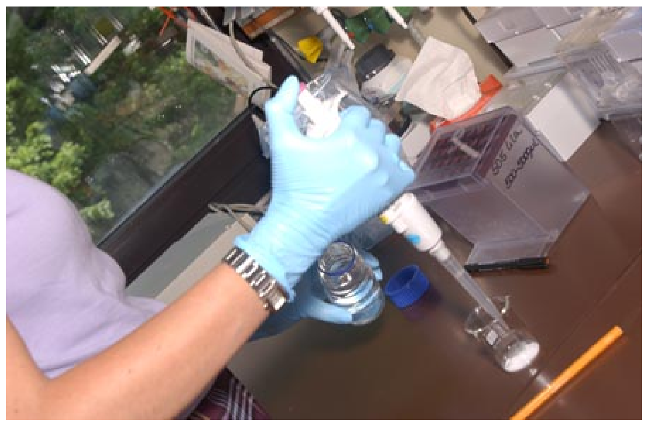


What are the techniques employed in Biotechnology?

- Molecular biology and Recombinant DNA Technology
- Sequencing, genotyping and transcriptomics
- Proteomics
- Metabolomics
- Structural biology and Systems biology
- Biotechnology
- Synthetic biology and protein engineering

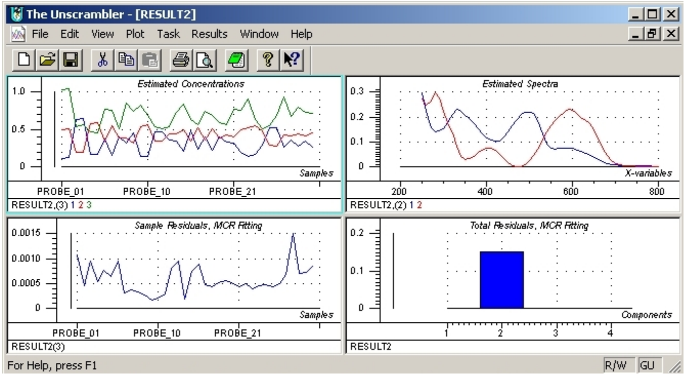


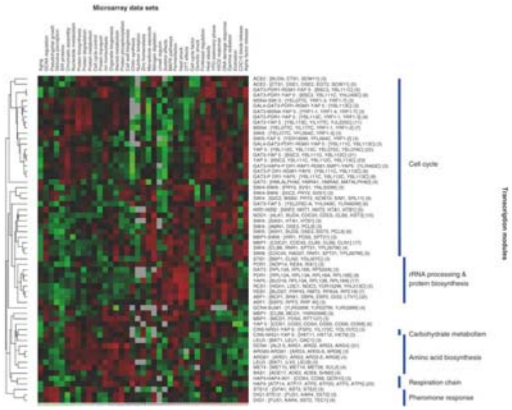


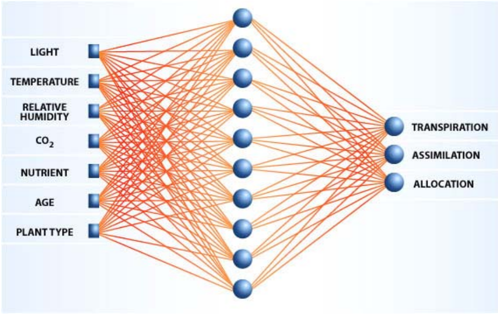


What are the techniques employed in Biotechnology?

- Statistical inference, regression and experiment design
- Multivariate data analysis
- Bayesian networks
- Neural networks
- Classification and clustering
- Dynamic models
- Associative rules, logic networks and grammars



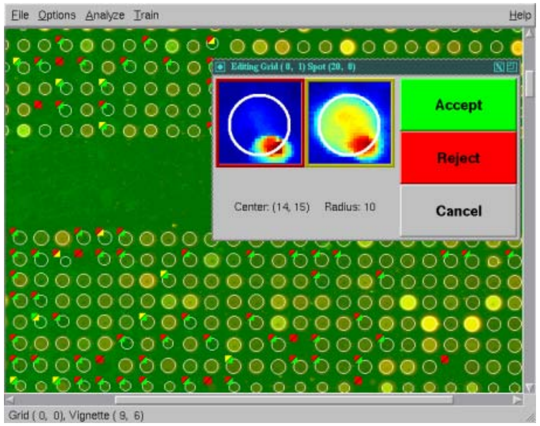


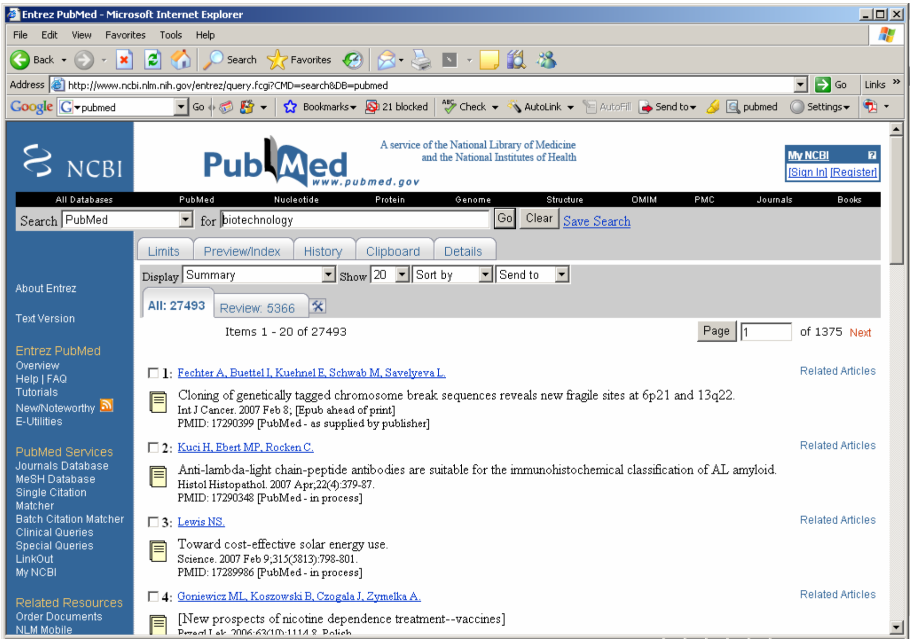


$$H(z) = \frac{Y(z)}{X(z)} = \frac{5 + 2z^{-1}}{1 + \frac{1}{2}z^{-1} - \frac{1}{4}z^{-2}}$$

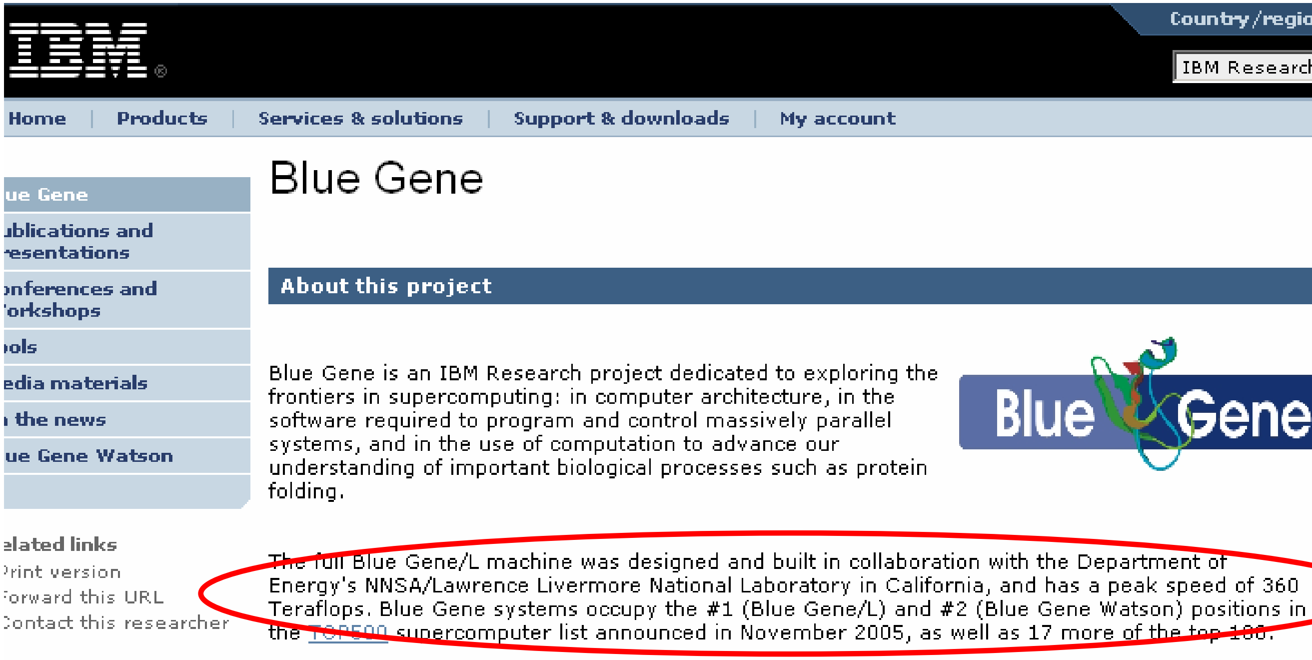
What are the techniques employed in Biotechnology?

- Bioinformatic databases and scientific literature analysis
- DNA, protein and structure analysis
- Arrays and Interaction network analysis





Can Biotechnology really be computational?



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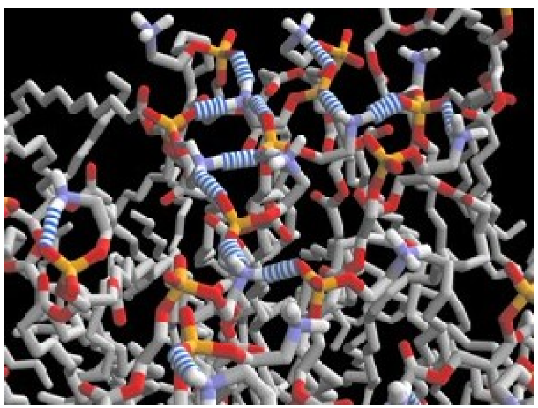
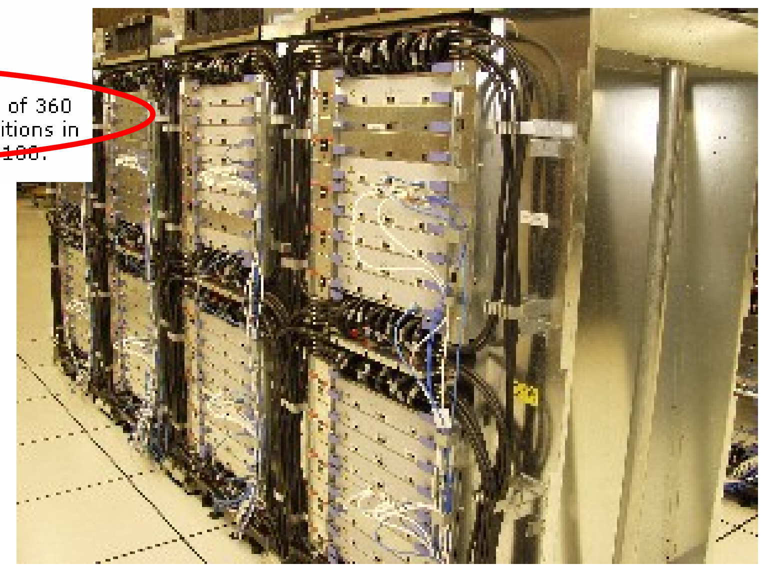
About this project

Blue Gene is an IBM Research project dedicated to exploring the frontiers in supercomputing: in computer architecture, in the software required to program and control massively parallel systems, and in the use of computation to advance our understanding of important biological processes such as protein folding.

Blue Gene

The full Blue Gene/L machine was designed and built in collaboration with the Department of Energy's NNSA/Lawrence Livermore National Laboratory in California, and has a peak speed of 360 Teraflops. Blue Gene systems occupy the #1 (Blue Gene/L) and #2 (Blue Gene Watson) positions in the TOP500 supercomputer list announced in November 2005, as well as 17 more of the top 100.





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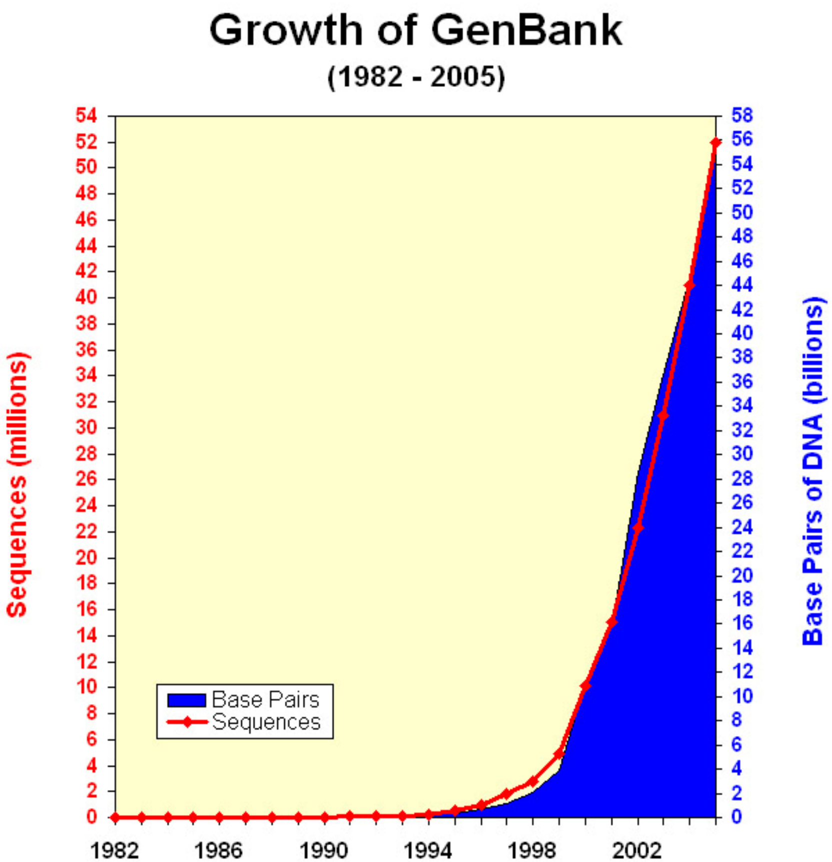

Published online 5 December 2006 *Nucleic Acids Research, 2007, Vol. 35, Database issue* **D3–D4**
doi:10.1093/nar/gkl1008

The Molecular Biology Database Collection: 2007 update

Michael Y. Galperin*

National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health, Bethesda, MD 20894, USA

Received November 1, 2006; Revised and Accepted November 2, 2006

ABSTRACT

The NAR online Molecular Biology Database Collection is a public resource that contains links to the databases described in this issue of *Nucleic Acids Research*, previous NAR database issues, as well as a selection of other molecular biology databases that are freely available on the web and might be useful to the molecular biologist. The 2007 update includes 968 databases, 110 more than the previous one. Many databases that have been described in earlier issues of NAR come with updated summaries, which reflect recent progress and, in some instances, an expanded scope of these databases. The complete database list and summaries are available online on the *Nucleic Acids Research* web site http://nar.oxfordjournals.org/.

total database list, which again held very nicely and showed surprising resilience.

In the comment to the last year's release of the NAR database collection (1), I have discussed the citation rates for various papers in the 2004 NAR database issue and noted that the high-citation rate of certain databases reflects their worldwide acceptance as *de facto* standards of protein functional annotation [UniProt, http://www.uniprot.org, No. 318, Ref. 2], domain structure [http://www.sanger.ac.uk/Software/Pfam/, No. 210, Ref. 3] and biomedical terminology [Gene Ontology, http://www.geneontology.org/, No. 487, Ref. 4]. However, citation data can be biased; e.g. in many articles use of information from publicly available databases is acknowledged by providing their URLs, or not acknowledged at all. Besides, some databases could be cited on the web sites and in new or obscure journals, not covered by the ISI Citation Index. With this in mind, I have tried here to use additional metrics for assessing the popularity of the NAR

Source: http://www.ncbi.nlm.nih.gov/Genbank/genbankstats.html

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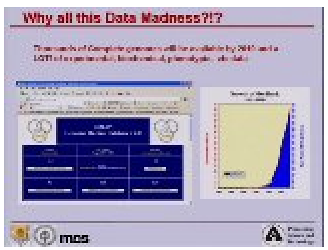
Can Biotechnology really be computational?

Keeping Up With The Human Genome
Google engEDU - 37 min - Dec 7, 2006
http://video.google.com/videoplay?docid=-3068967863312207867

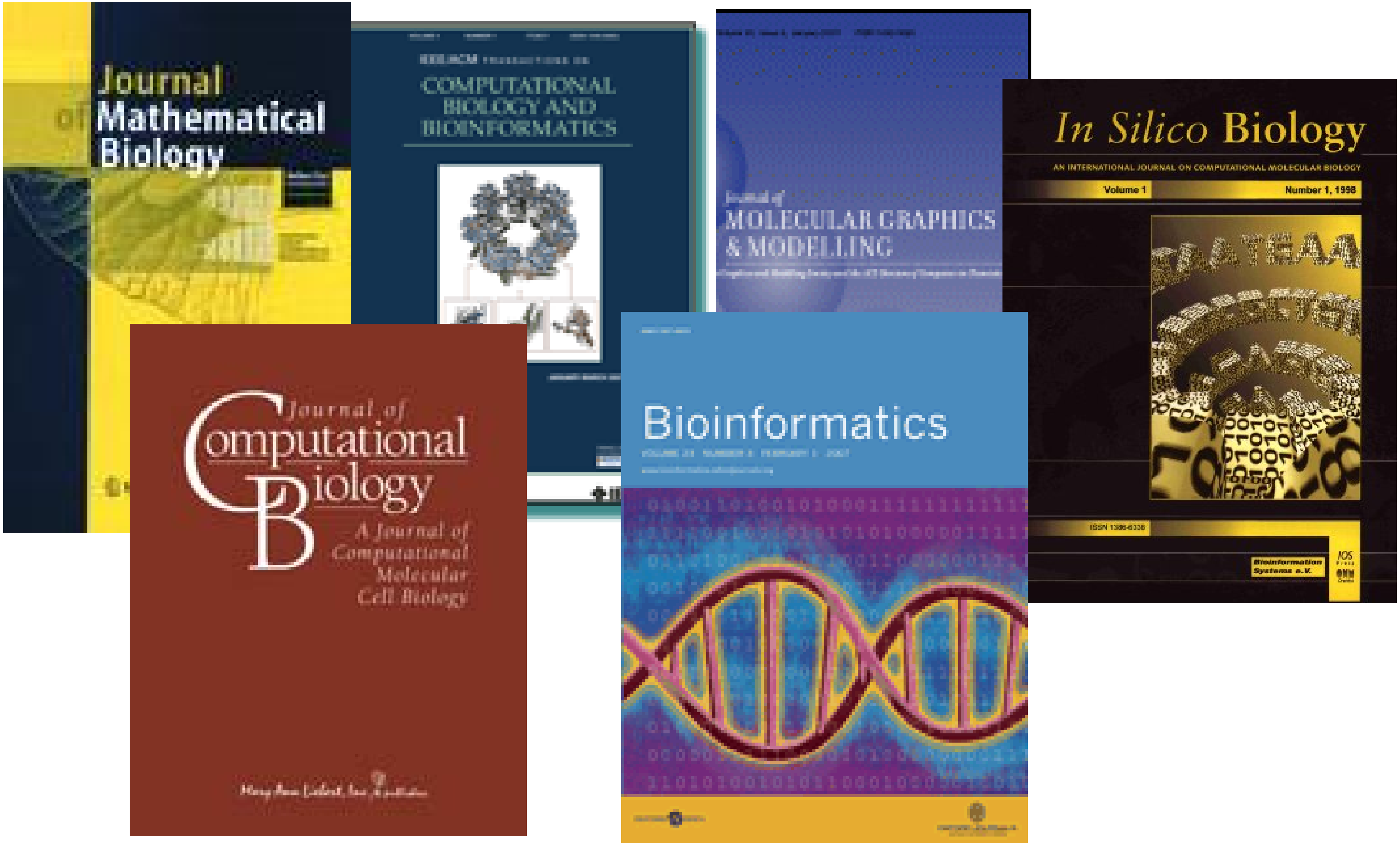
Mysteries of the Human Genome
Google engEDU - 1 hr 3 min - Oct 23, 2006
http://video.google.com/videoplay?docid=-4253577361254801147



Grid-based Integrated Bioinformatics Systems for High Throughput
Google engEDU - 45 min - Sep 15, 2006
http://video.google.com/videoplay?docid=86918197086997488

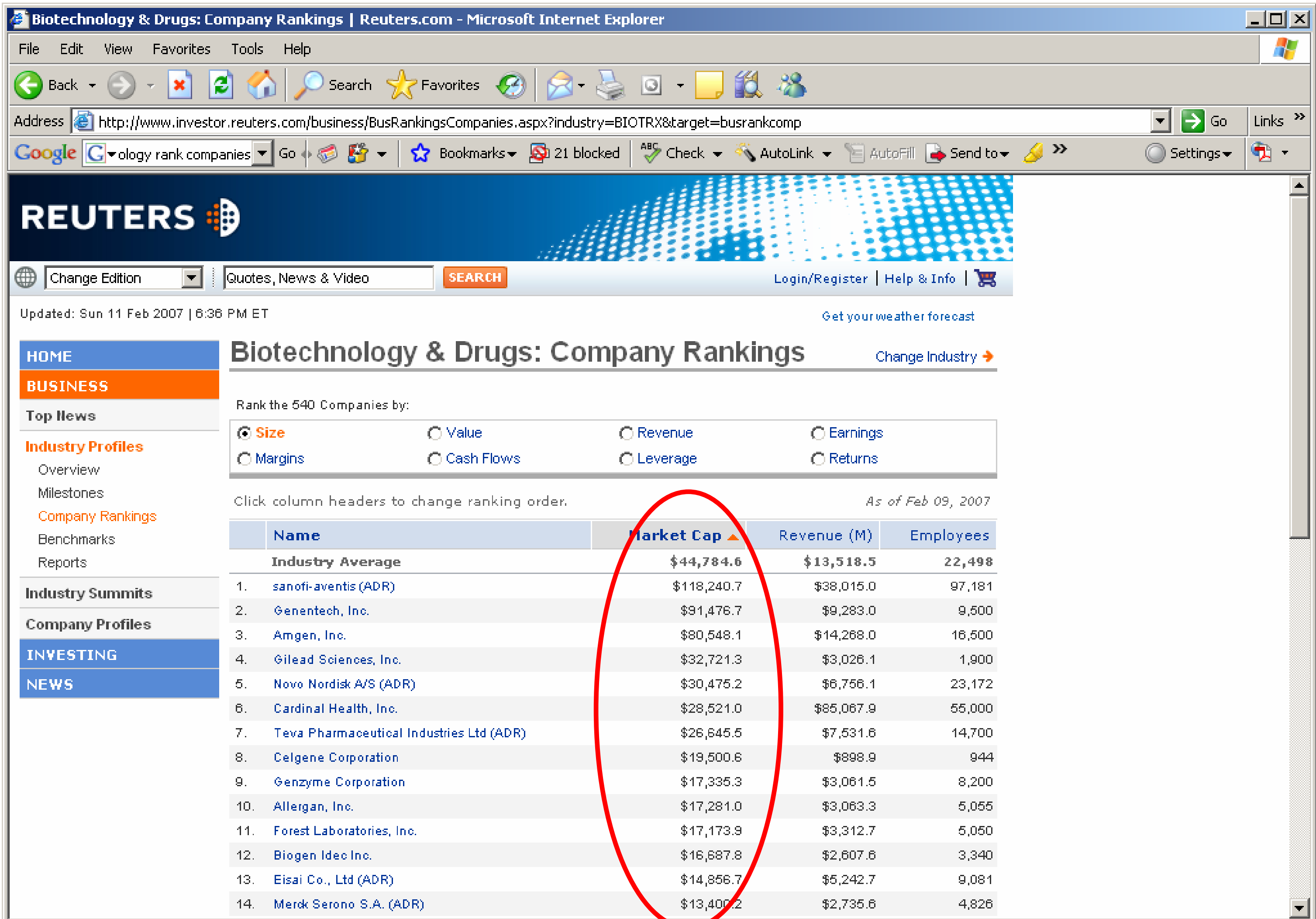
Open Source Drug Discovery for Neglected Diseases
Google engEDU - 50 min - Apr 7, 2006
http://video.google.com/videoplay?docid=-6203430655396416135

Can Biotechnology really be computational?



How is it to work in a Biotechnology company?

How are the companies in Biotechnology?



Biotechnology & Drugs: Company Rankings | Reuters.com - Microsoft Internet Explorer

http://www.investor.reuters.com/business/BusRankingsCompanies.aspx?industry=BIOTRX&target=busrankcomp

REUTERS

Updated: Sun 11 Feb 2007 | 6:36 PM ET

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Biotechnology & Drugs: Company Rankings

Change Industry

Rank the 540 Companies by:

Size | Value | Revenue | Earnings | Margins | Cash Flows | Leverage | Returns

Click column headers to change ranking order. *As of Feb 09, 2007*

	Name	Market Cap	Revenue (M)	Employees
	Industry Average	$44,784.6	$13,518.5	22,498
1.	sanofi-aventis (ADR)	$118,240.7	$38,015.0	97,181
2.	Genentech, Inc.	$91,476.7	$9,283.0	9,500
3.	Amgen, Inc.	$80,548.1	$14,268.0	16,500
4.	Gilead Sciences, Inc.	$32,721.3	$3,026.1	1,900
5.	Novo Nordisk A/S (ADR)	$30,475.2	$6,756.1	23,172
6.	Cardinal Health, Inc.	$28,521.0	$85,067.9	55,000
7.	Teva Pharmaceutical Industries Ltd (ADR)	$26,645.5	$7,531.6	14,700
8.	Celgene Corporation	$19,500.6	$898.9	944
9.	Genzyme Corporation	$17,335.3	$3,061.5	8,200
10.	Allergan, Inc.	$17,281.0	$3,063.3	5,055
11.	Forest Laboratories, Inc.	$17,173.9	$3,312.7	5,050
12.	Biogen Idec Inc.	$16,687.8	$2,607.6	3,340
13.	Eisai Co., Ltd (ADR)	$14,856.7	$5,242.7	9,081
14.	Merck Serono S.A. (ADR)	$13,400.2	$2,735.6	4,826

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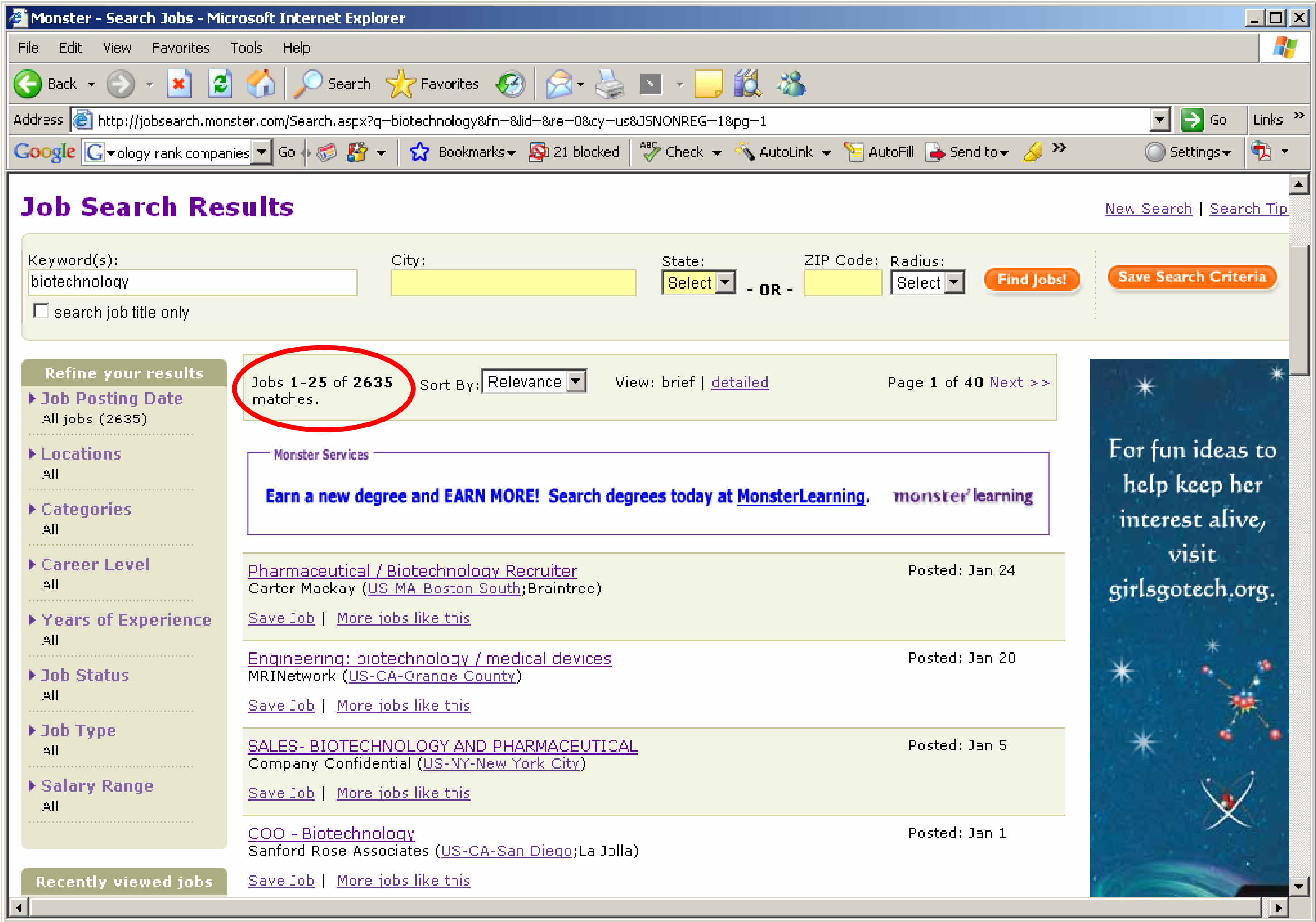
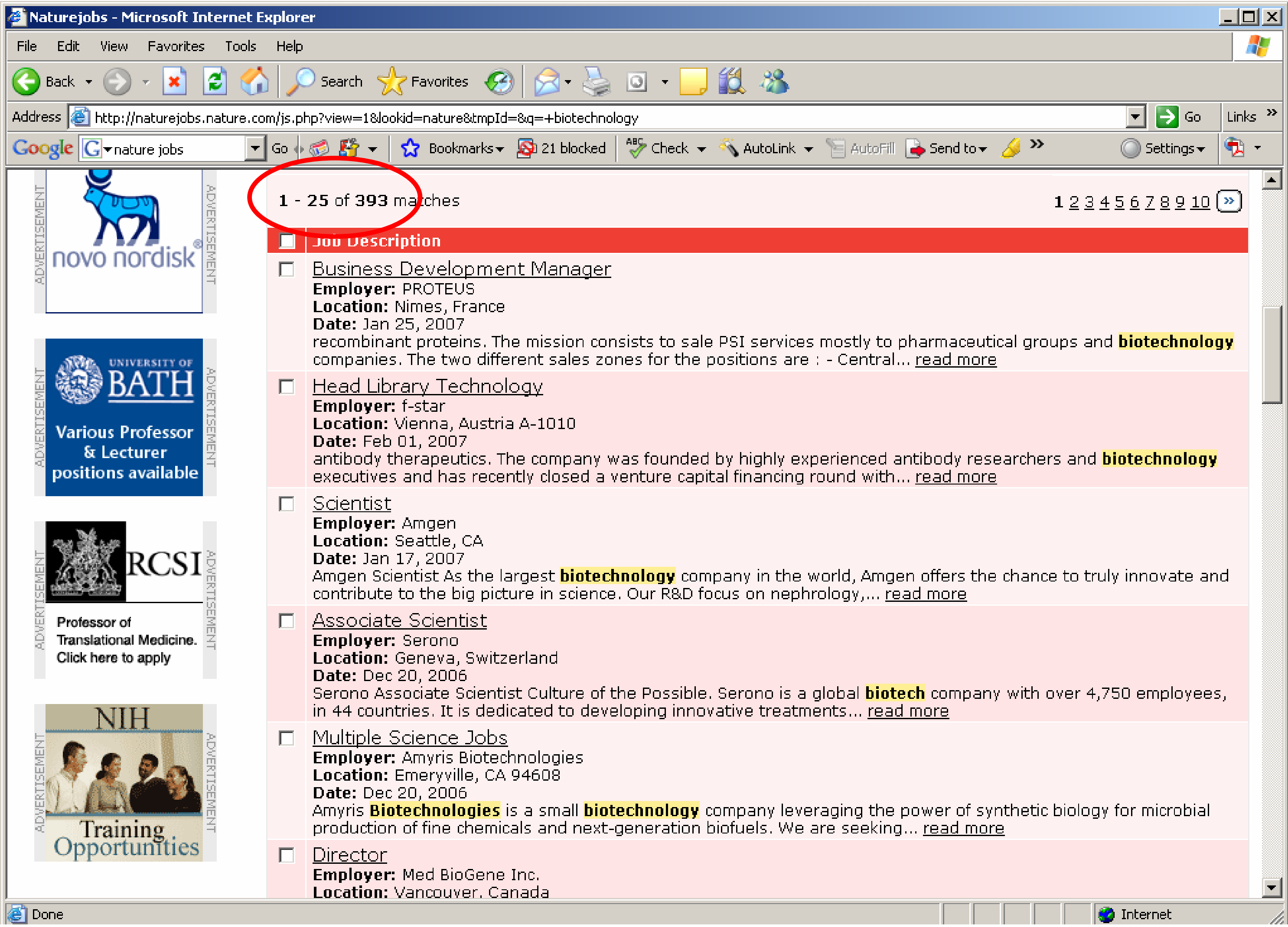
Are there jobs in Biotechnology?



Are there jobs in Biotechnology?



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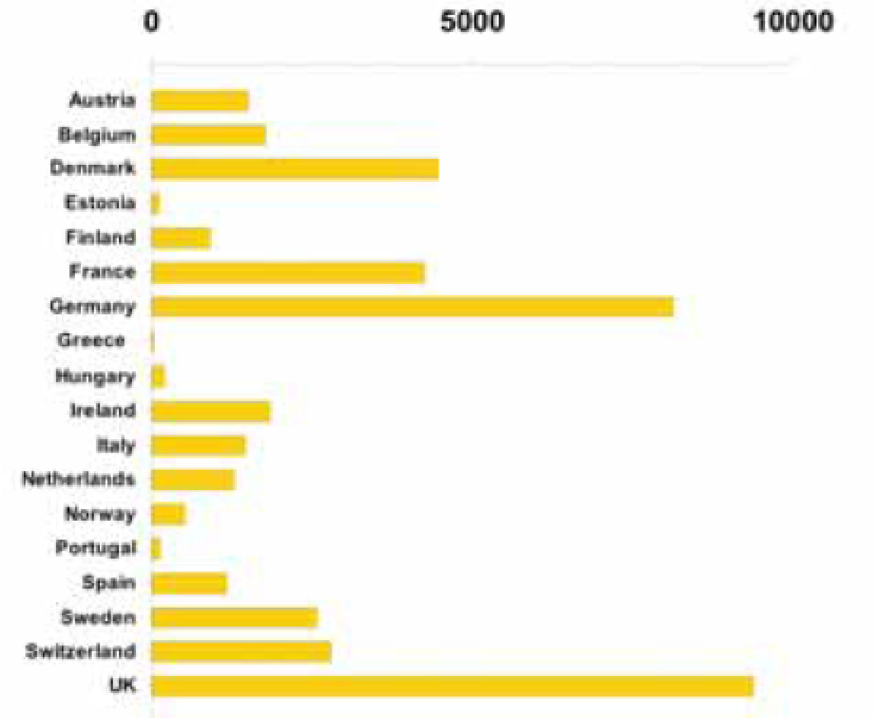
Biotechnology in Europe

Number of Research and Development Employees – 2004



Source: Critical I Limited

Europe's newest companies (under 5 years old) are dotted around the continent

Source: Critical I Limited

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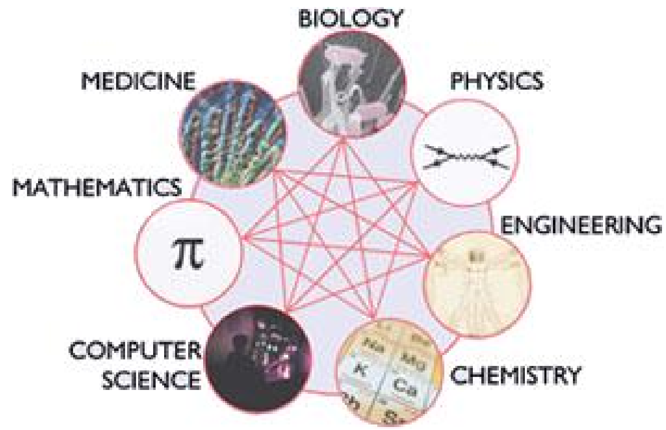
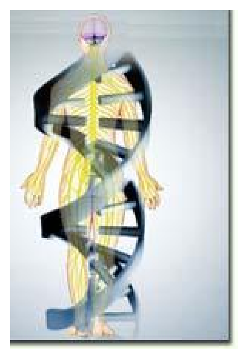
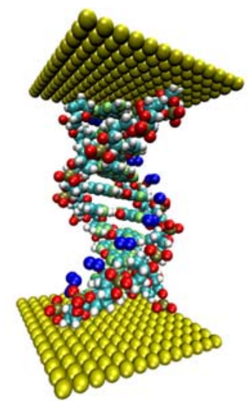
Conclussions

- Multidisciplinary technology
- Modern technology
- Multiple applications







Conclussions

- A growing/stable industry

- A lot of work to do

Source: Critical I Limited