Science and Research in the 21st Century and its Success in Technology

Peter Schuster

Institut für Theoretische Chemie, Universität Wien, Austria
and
The Santa Fe Institute, Santa Fe, New Mexico, USA

EU Forest Based Technology Platform

Admont, 02.05.2006

Web-Page for further information:

http://www.tbi.univie.ac.at/~pks

1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary.

5. New technologies yield the largest profits where the discoveries and innovations were made.

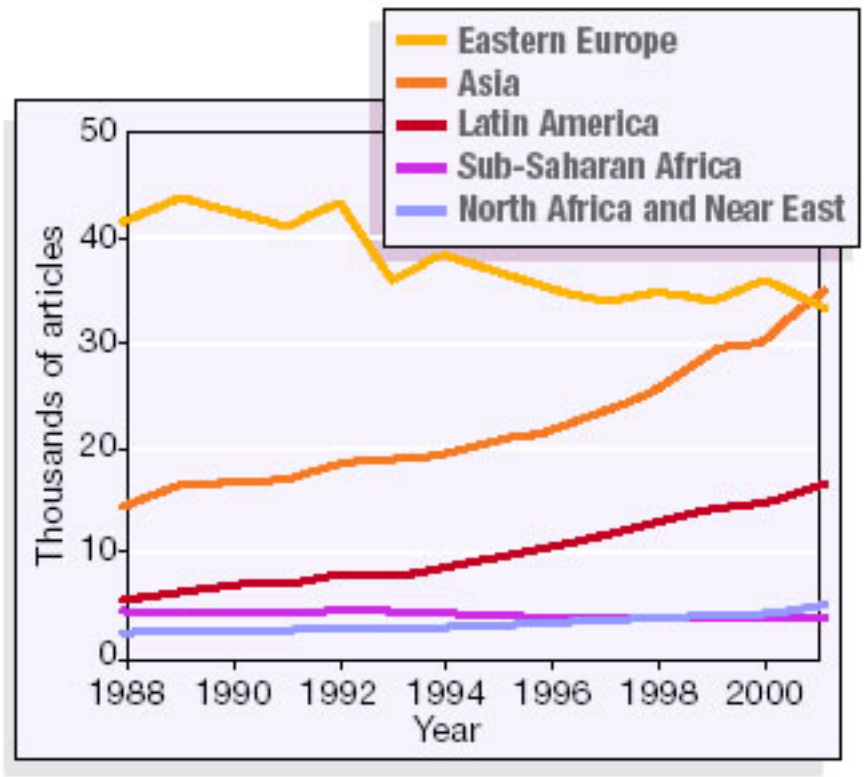
1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary.

5. New technologies yield the largest profits where the discoveries and innovations were made.



News in brief: “Latin America records rapid rise in research publications.” *Nature* **432**:8, 2004.

Alice in Wonderland:

... The Red Queen to Alice: „Now, here, you see, it takes all the running you can do to keep in the same place. ...“

Van Valen, L. A New Evolutionary Law, *Evolutionary Theory* **1**:1-30, 1973.

Carrol, L. *Through the looking glass and what Alice found there*. Macmillan, London 1872.

1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

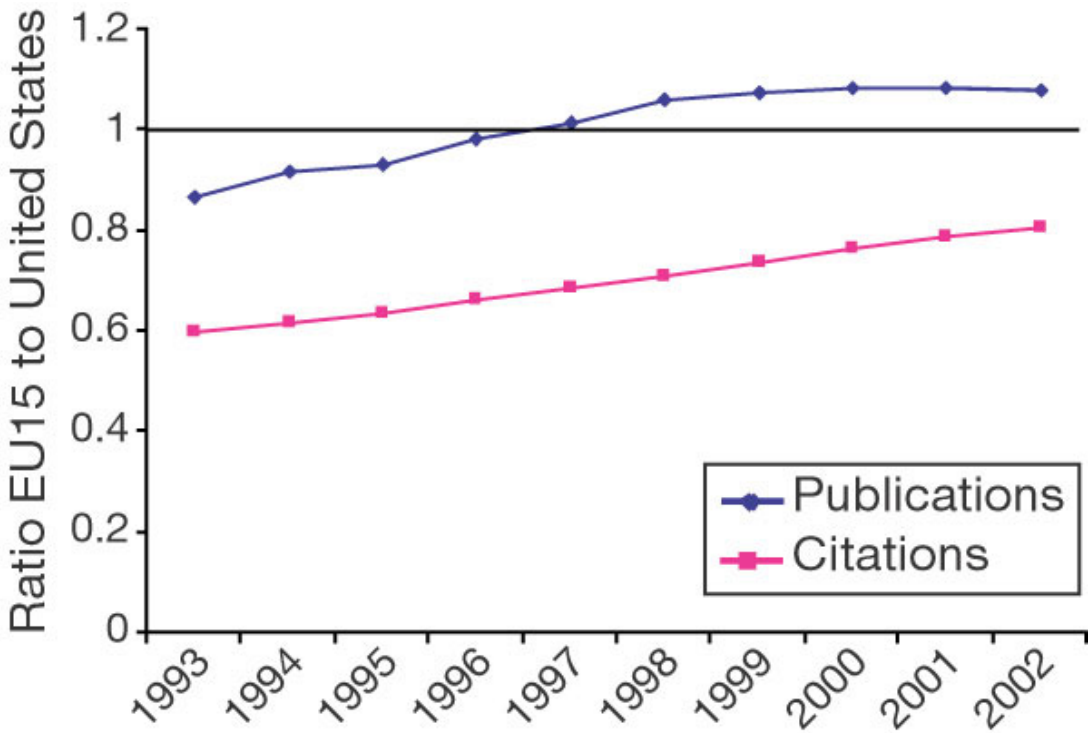
3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary.

5. New technologies yield the largest profits where the discoveries and innovations were made.

Governmental expenses for research and development in percentage of GDP

Country	Year	Public financial support (% GDP)
Israel	1996	2.90
	2002	**5.11**
Sweden	1997	3.54
	2001	4.27
Finland	1996	2.54
	2002	**3.46**
Japan	1996	2.76
	2002	**3.11**
Iceland	1997	1.88
	2002	**3.11**
USA	1996	2.55
	2002	**2.67**
Switzerland	1996	2.73
	2000	2.63
Germany	1996	2.28
	2002	**2.64**
Denmark	1996	1.85
	2002	**2.51**
Belgium	1996	1.80
	2002	**2.23**
Austria	1996	1.60
	2002	**2.21**



King, D.A. The scientific impact of nations. What different countries get for their research spending. *Nature* **430**:311-316, 2004.

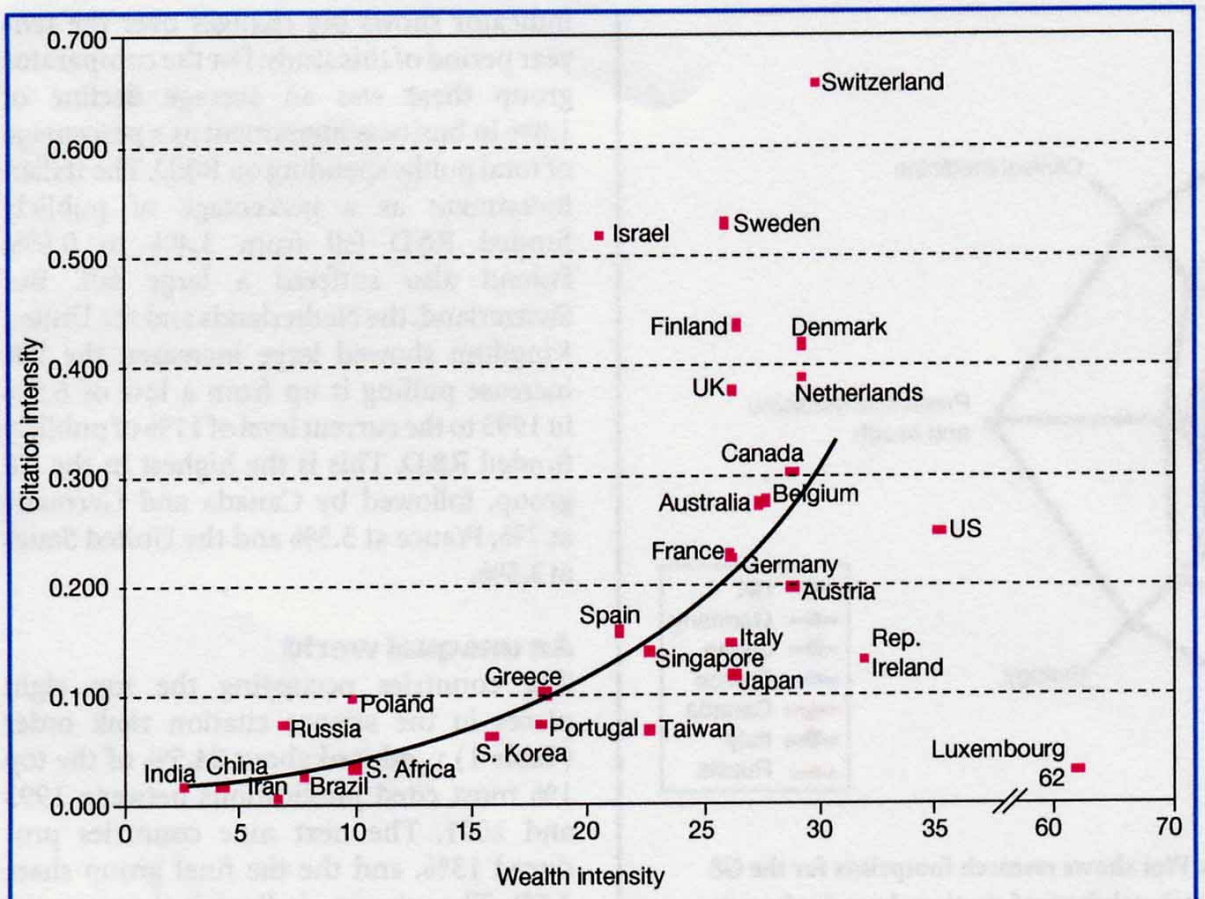


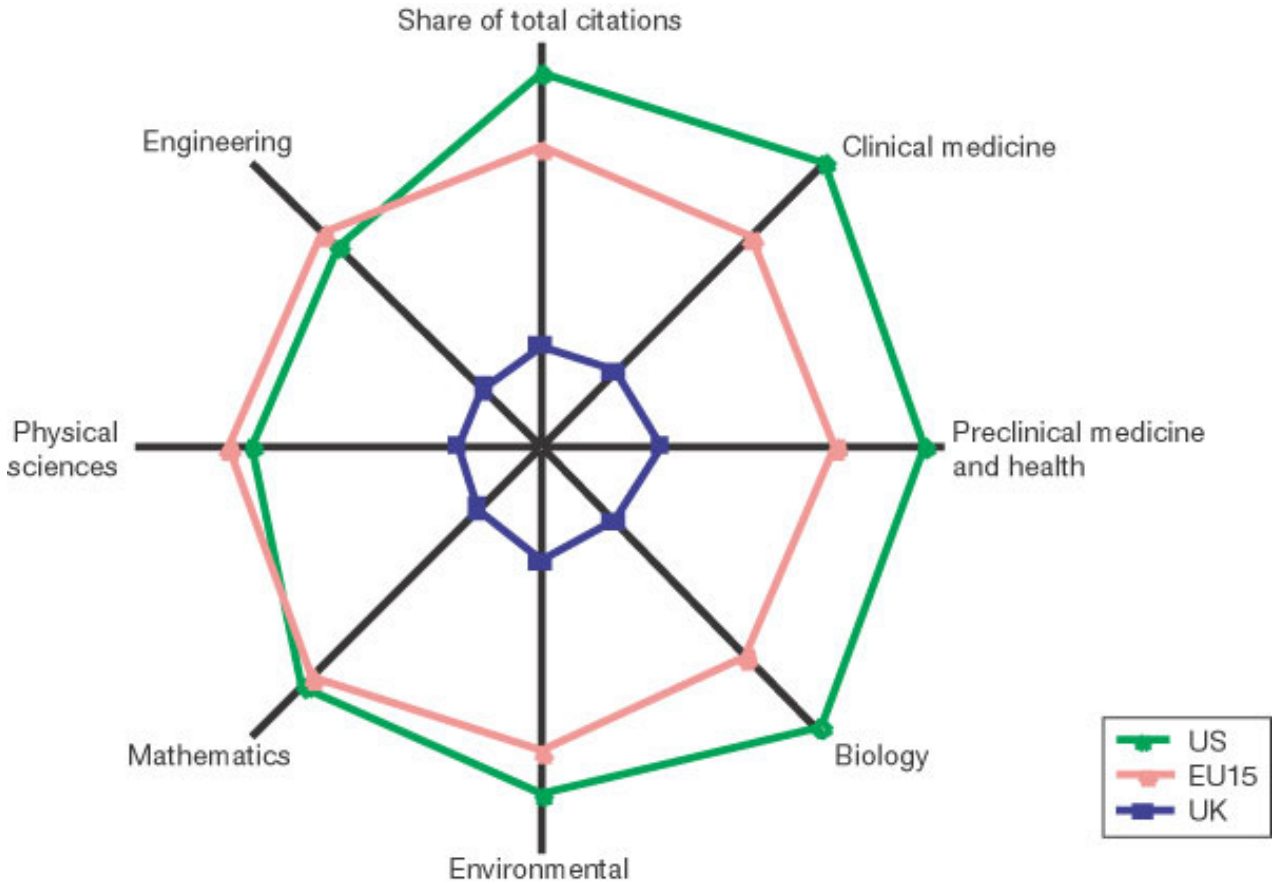
Figure 2 **Comparing economic and scientific wealth. National science citation intensity, measured as the ratio of the citations to all papers to the national GDP, shown as a function of the national wealth intensity, or GDP per person, for the 31 nations in the comparator group. GDP and wealth intensity are given in thousands of US dollars at 1995 purchasing-power parity. Sources: Thomson ISI, OECD and the World Bank.**

GDP = gross domestic product

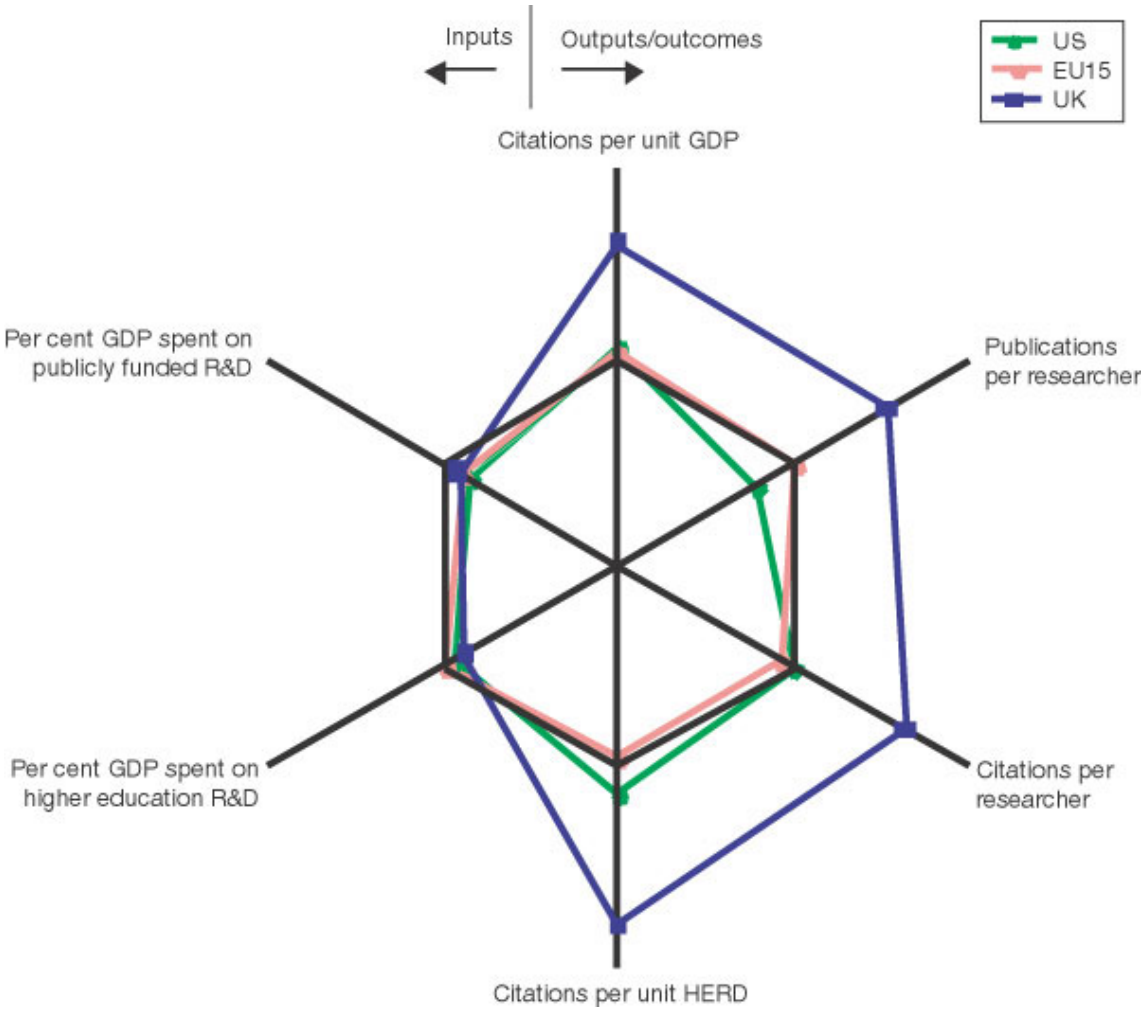
wealth intensity = GDP/person

citation intensity = #citations/GDP

King, D.A. The scientific impact of nations. What different countries get for their research spending. *Nature* **430**:311-316, 2004.



King, D.A. The scientific impact of nations. What different countries get for their research spending. *Nature* **430**:311-316, 2004.



GDP = gross domestic product

citation intensity = #citations/GDP

HERD = higher educational funding of research and development

King, D.A. The scientific impact of nations. What different countries get for their research spending. *Nature* **430**:311-316, 2004.

Table 3 **Comparisons of private sector R&D spending and the output of PhDs and researchers***

Country	*BERD†*	*BERD as % of GDP*	*PhDs*	*PhDs per head of population*	*Full-time researchers*	*Full-time researchers per 1,000 employed*
Japan	65,726	2.12	10,962	0.08	644,208	9.59
US	169,228	1.97	44,955	0.17	1,148,271	8.17
Germany	31,013	1.66	24,940	0.30	238,944	5.93
France	18,186	1.38	10,056	0.17	156,004	5.99
UK	15,048	1.22	11,253	0.19	147,035	5.02
EU	95,733	1.19	6,323	0.18	784,066	5.6
Canada	8,343	1.06	3,871	0.13	90,245	5.88
Russia	6,577	0.72	-	-	-	-
Italy	6,569	0.53	3,494	0.06	69,621	3.09

All figures show average for 1997–2001, except PhDs, for which data are only available for 1998–2000.
*Researchers are defined as professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned, after the OECD/Frascati.
†Business enterprise research and development, in US$ million at 1995 prices, adjusted for purchasing power.

GDP = gross domestic product

HERD = higher educational funding of research and development

BERD = business enterprise research and development

King, D.A. The scientific impact of nations. What different countries get for their research spending. *Nature* **430**:311-316, 2004.

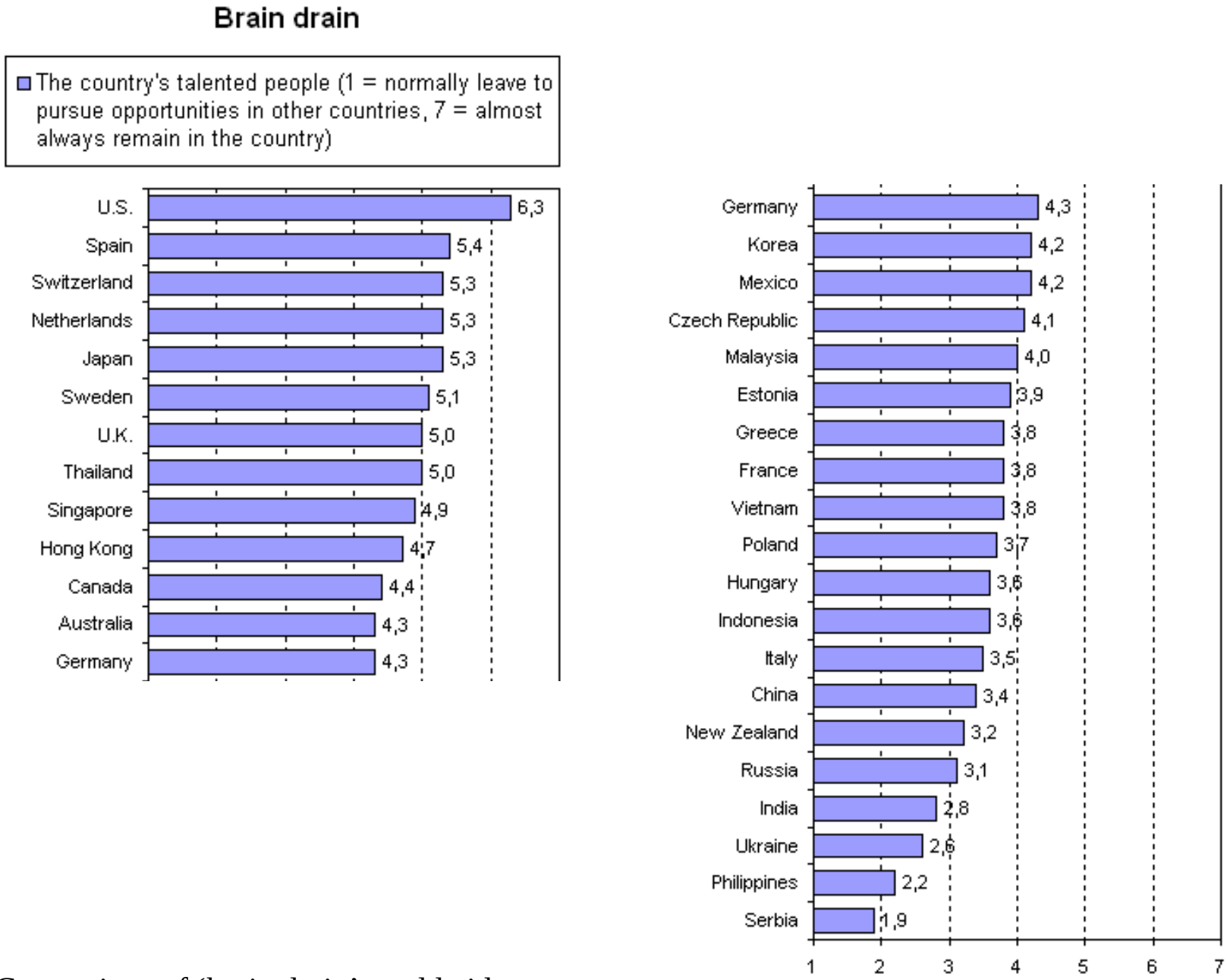
1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary.

5. New technologies yield the largest profits where the discoveries and innovations were made.



Comparison of ‘brain drain’ worldwide

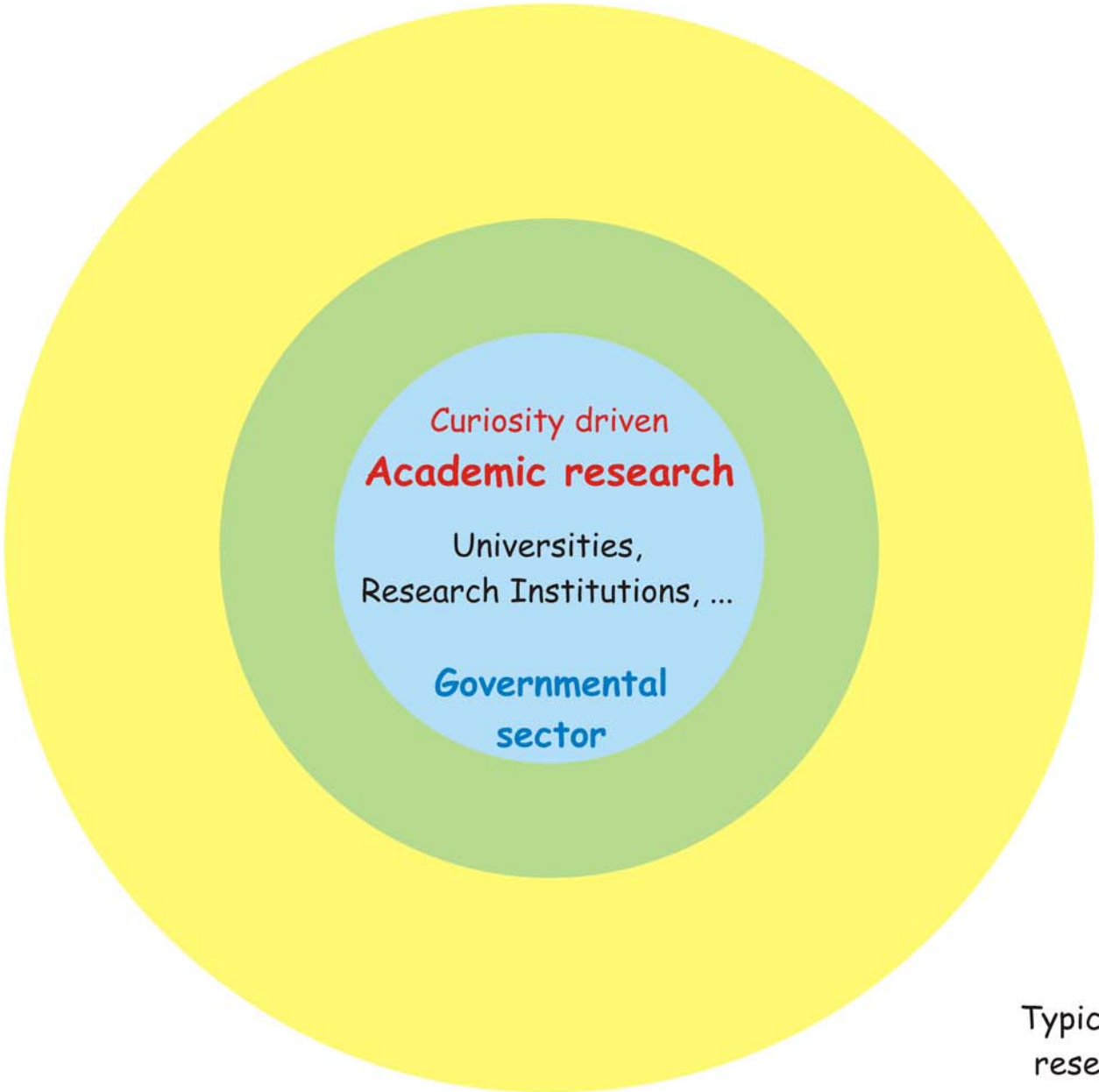
1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

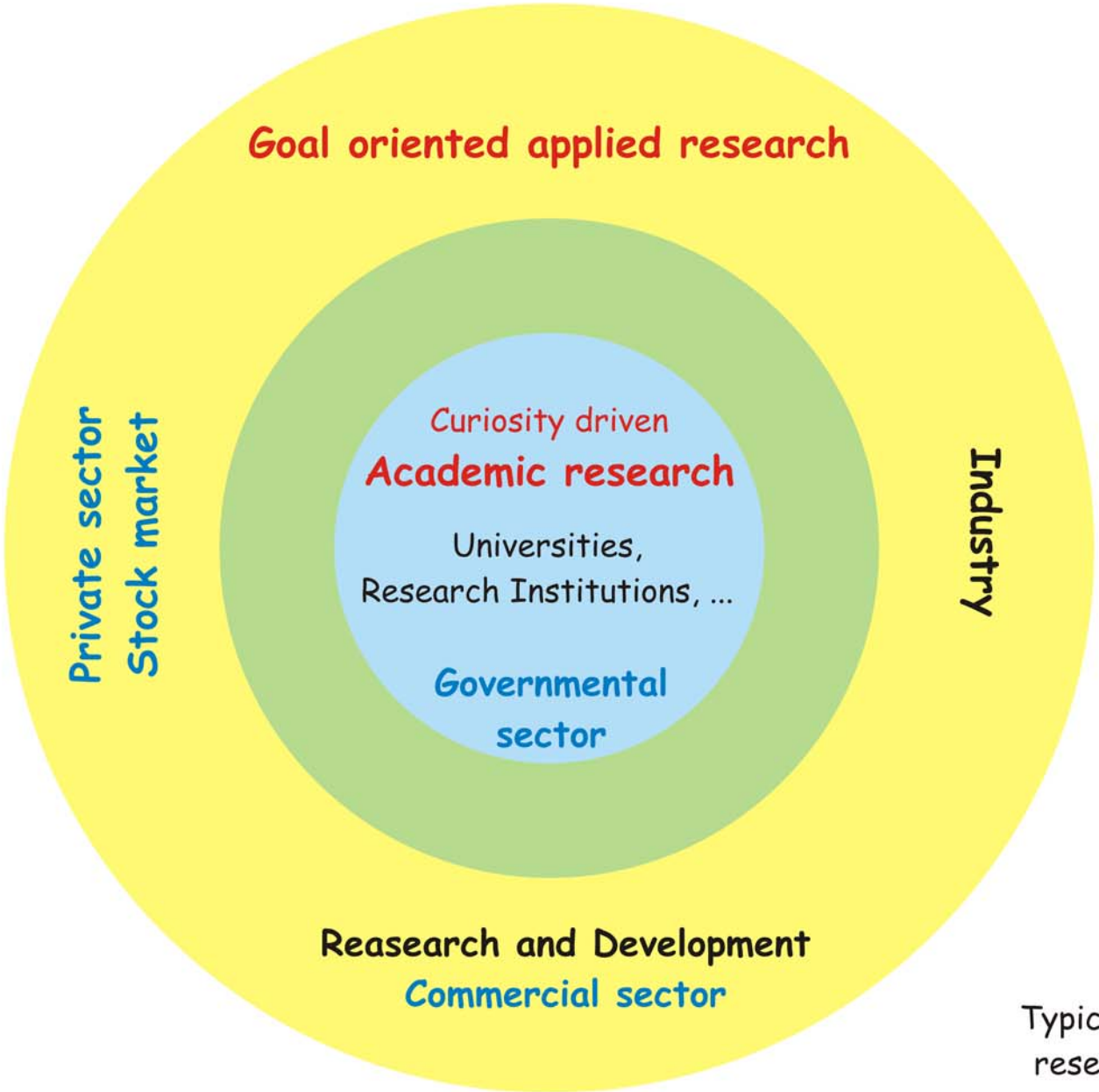
3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary

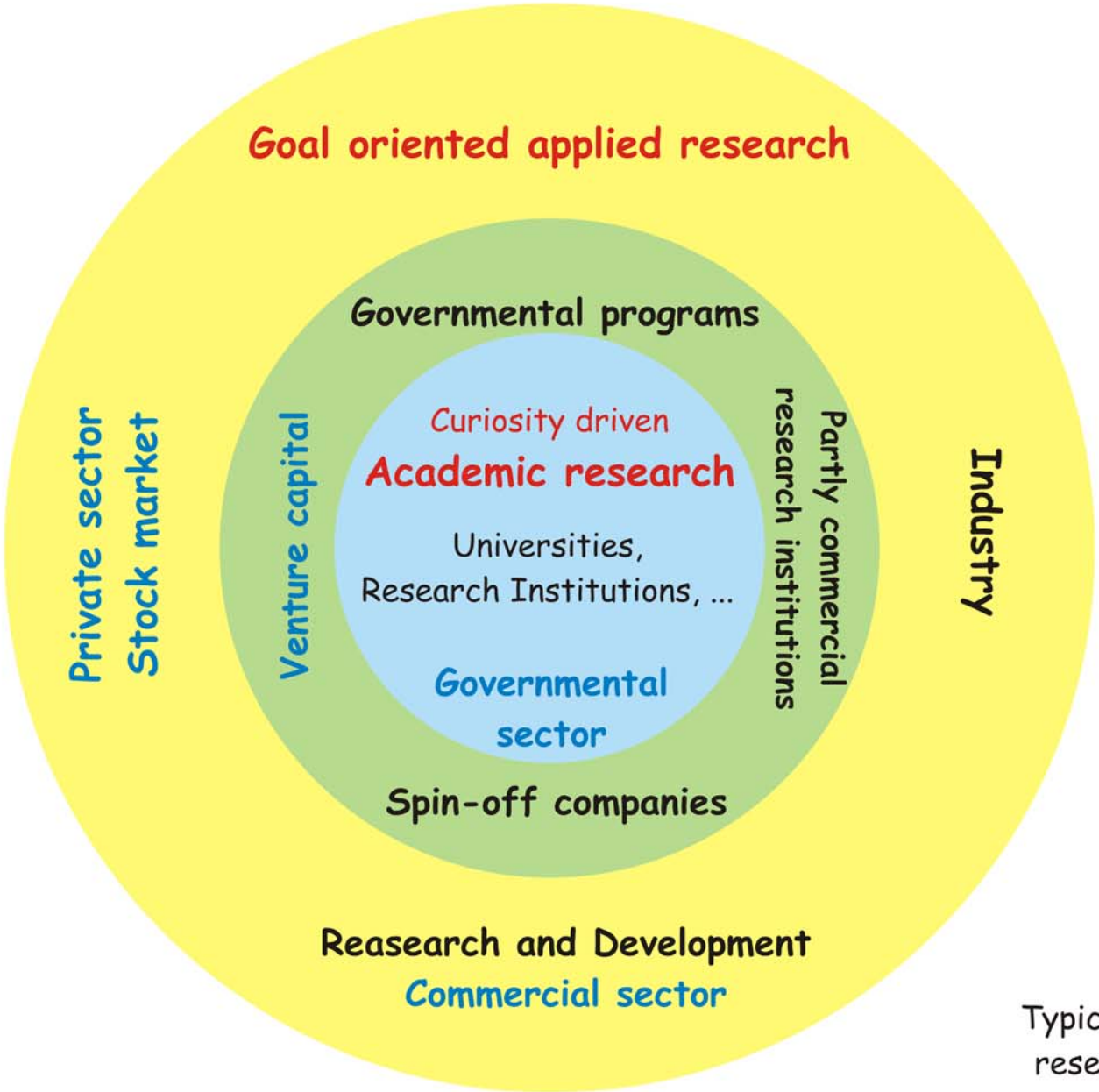
5. New technologies yield the largest profits where the discoveries and innovations were made.



Typical concept of governmental research planning in the 1990s



Typical concept of governmental research planning in the 1990s



Typical concept of governmental research planning in the 1990s

There is no recipe for success in planning discovery and innovation but there are rules for failure with high probability:

1. **Rigid planning of research:** Five year plans with pre-assigned application goals for basic research (DDR).

2. **No research plan at all:** 'Coordination-free science' commonly leads to sub-critical research entities, which cannot compete on a worldwide scale.

3. **Barriers between disciplines:** Modern innovation makes use of knowledge from all disciplines from humanities and social sciences to physics and mathematics. Universities are not yet preparing for research across disciplines.

4. **Contact-hostile grouping of researchers:** In curiosity driven research scientists need personal contacts almost every day.

How to get advice from the successful entrepreneur:

Don't listen what he is telling, watch what he is doing, and try to learn from his failures and his successes.

1. New major players are appearing on the worldwide stage of research and technology.

2. More financial support alone is no guarantee for success in research politics.

3. Excellent career opportunities for young scientists will help to invert the brain drain.

4. Innovative research and knowledge transfer are very often trans-disciplinary.

5. New technologies yield the largest profits where the discoveries and the innovations were made.

1885 – Separation of 'didym' into ***neodym*** and ***praseodym.***

1885 – Gas burner mantle for incandescent lighting.

1890 – First industrial process using powder metallurgy.

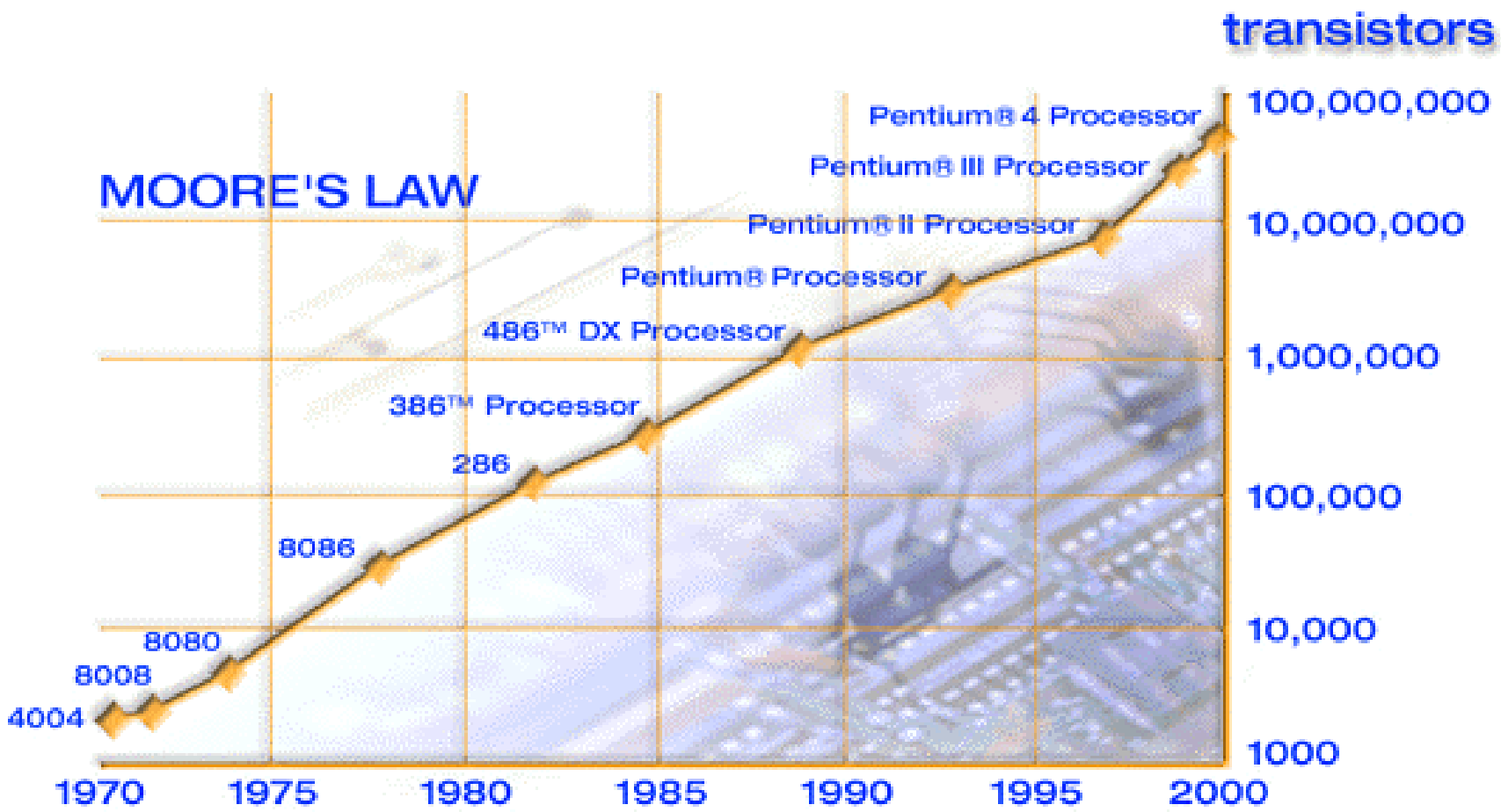
1898 – Electric bulb with osmium filament.

1903 – Pyrophoric alloys (cerium-iron) used as flints.

1907 – Foundation of the 'Treibacher Chemische Werke GmbH' in Treibach-Althofen for the production of ferrocerium-lighter flints under the trade name 'Original Auermetall'.

2006 – About one hundred years later the 'Treibacher Chemische Werke' are still flourishing and represent the major industry and employer in the whole region.

Source: Auer von Welsbach-Museum, Treibach-Althofen, Kaernten, Austria.


transistors
MOORE'S LAW
Pentium® 4 Processor
Pentium® III Processor
Pentium® II Processor
Pentium® Processor
486™ DX Processor
386™ Processor
286
8086
8080
8008
4004
100,000,000
10,000,000
1,000,000
100,000
10,000
1000
1970
1975
1980
1985
1990
1995
2000

TOP 30 COUNTRIES WITH THE HIGHEST INTERNET PENETRATION RATE

#	Country or Region	Penetration (% Population)	Internet Users Latest Data	Population (2006 Est.)	Source and Date of Latest Data
1	New Zealand	76.3 %	3,200,000	4,195,729	ITU - Sept/05
2	Iceland	75.9 %	225,600	297,072	ITU - Sept/05
3	Sweden	74.9 %	6,800,000	9,076,757	ITU - Oct/05
4	Falkland Islands	70.4 %	1,900	2,699	CIA - Dec/02
5	Denmark	69.4 %	3,762,500	5,425,373	ITU - Sept/05
6	Hong Kong	69.2 %	4,878,713	7,054,867	Nielsen//NR Feb./05
7	United States	68.6 %	205,326,680	299,093,237	Nielsen//NR Jan/06
8	Australia	68.4 %	14,189,557	20,750,052	Nielsen//NR Jan/06
9	Canada	67.9 %	21,900,000	32,251,238	eTForecasts Dec/05
10	Norway	67.8 %	3,140,000	4,632,911	C.I.Almanac Mar/05
11	Singapore	67.2 %	2,421,800	3,601,745	ITU - Oct/05
12	Japan	67.2 %	86,300,000	128,389,000	eTForecasts Dec/05
13	Korea, (South)	67.0 %	33,900,000	50,633,265	eTForecasts Dec/05
14	Greenland	66.5 %	38,000	57,185	ITU - Oct/05
15	Switzerland	66.0 %	4,944,438	7,488,533	Nielsen//NR Jan/06
16	Netherlands	65.9 %	10,806,328	16,386,216	Nielsen//NR Jun/04
17	Faroe Islands	64.5 %	32,000	49,598	ITU - Dec/05
18	United Kingdom	62.9 %	37,800,000	60,139,274	ITU - Oct/05

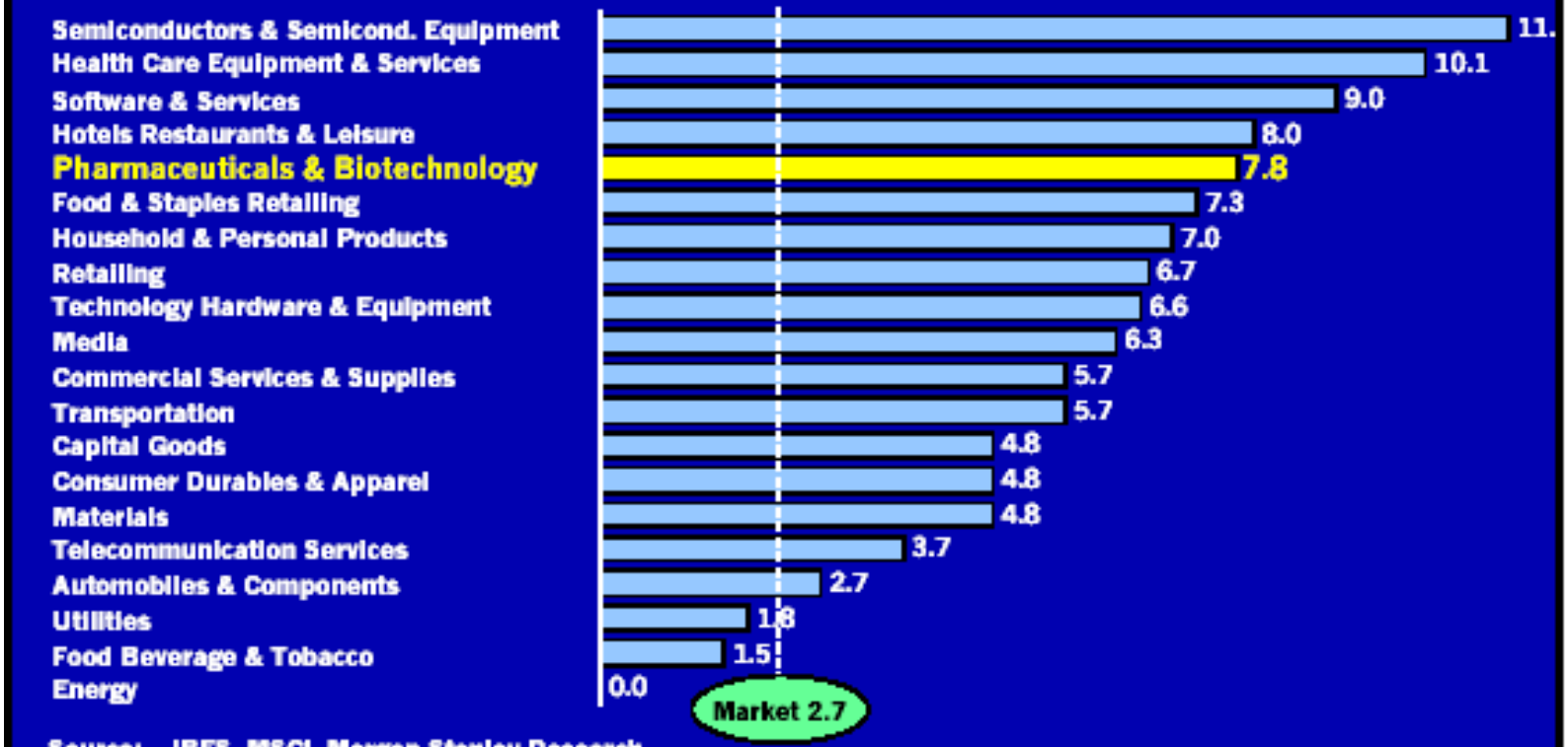
TOP 30 COUNTRIES WITH THE HIGHEST INTERNET PENETRATION RATE

#	Country or Region	Penetration (% Population)	Internet Users Latest Data	Population (2006 Est.)	Source and Date of Latest Data
15	Switzerland	66.0 %	4,944,438	7,488,533	Nielsen//NR Jan/06
16	Netherlands	65.9 %	10,806,328	16,386,216	Nielsen//NR Jun/04
17	Faroe Islands	64.5 %	32,000	49,598	ITU - Dec/05
18	United Kingdom	62.9 %	37,800,000	60,139,274	ITU - Oct/05
19	Finland	62.5 %	3,286,000	5,260,970	ITU - Sept/05
20	Bermuda	60.7 %	39,000	64,211	ITU - Oct/05
21	Taiwan	60.3 %	13,800,000	22,896,488	CIA Mar/05
22	Germany	59.0 %	48,721,997	82,515,988	Nielsen//NR Jan/06
23	Luxembourgh	58.9 %	270,800	459,393	ITU - Sept/05
24	Portugal	58.0 %	6,090,000	10,501,051	C.I.Almanac Mar/05
25	Austria	56.8 %	4,650,000	8,188,806	C.I.Almanac Mar/05
26	Liechtenstein	56.7 %	20,000	35,276	CIA - Dec/02
27	Guernsey & Alder.	56.5 %	36,000	63,683	ITU - Oct/05
28	Barbados	56.2 %	150,000	266,731	ITU - Sept/05
29	Ireland	50.7 %	2,060,000	4,065,631	C.I.Almanac Mar./05
30	Estonia	50.0 %	670,000	1,339,157	ITU - Sept/05
TOP 30 in Penetration		66.2 %	519,461,313	785,179,437	IWS - Mar/06
Rest of the World		8.8 %	503,401,994	5,714,517,623	IWS - Mar/06
World Total Users		15.7 %	1,022,863,307	6,499,697,060	IWS - Mar/06

NOTES: (1) Only countries with a Penetration Rate higher than 50% qualify for this list. At present only 31 countries and territories meet this condition. Malta was removed from the list till its statistics are verified. (2) The Internet Penetration Statistics were updated as of March 31, 2006. (3) Population numbers are based on the data contained in world-gazetteer.com. (4) The most recent usage information comes from data published by Nielsen//NetRatings , ITU , Computer Industry Almanac and other trustworthy sources. For definitions please refer to the surfing guide. (5) Data from this site may be cited, giving due credit and establishing an active link back to Internet World Stats.

Pharmaceuticals Continues to Expand as One of the Fastest Growing Industries

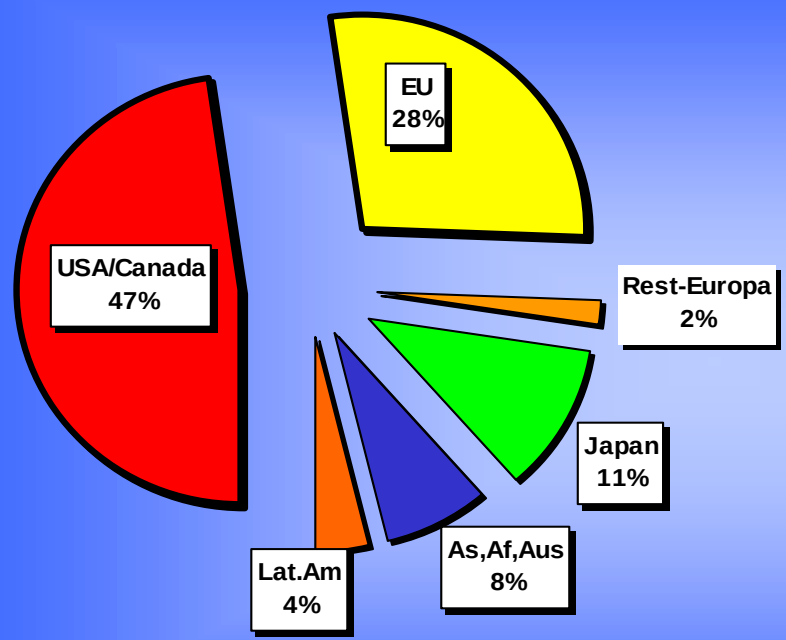
Global sector and market growth 2004-2006E (CAGR) in %



Source: IBES, MSCI, Morgan Stanley Research

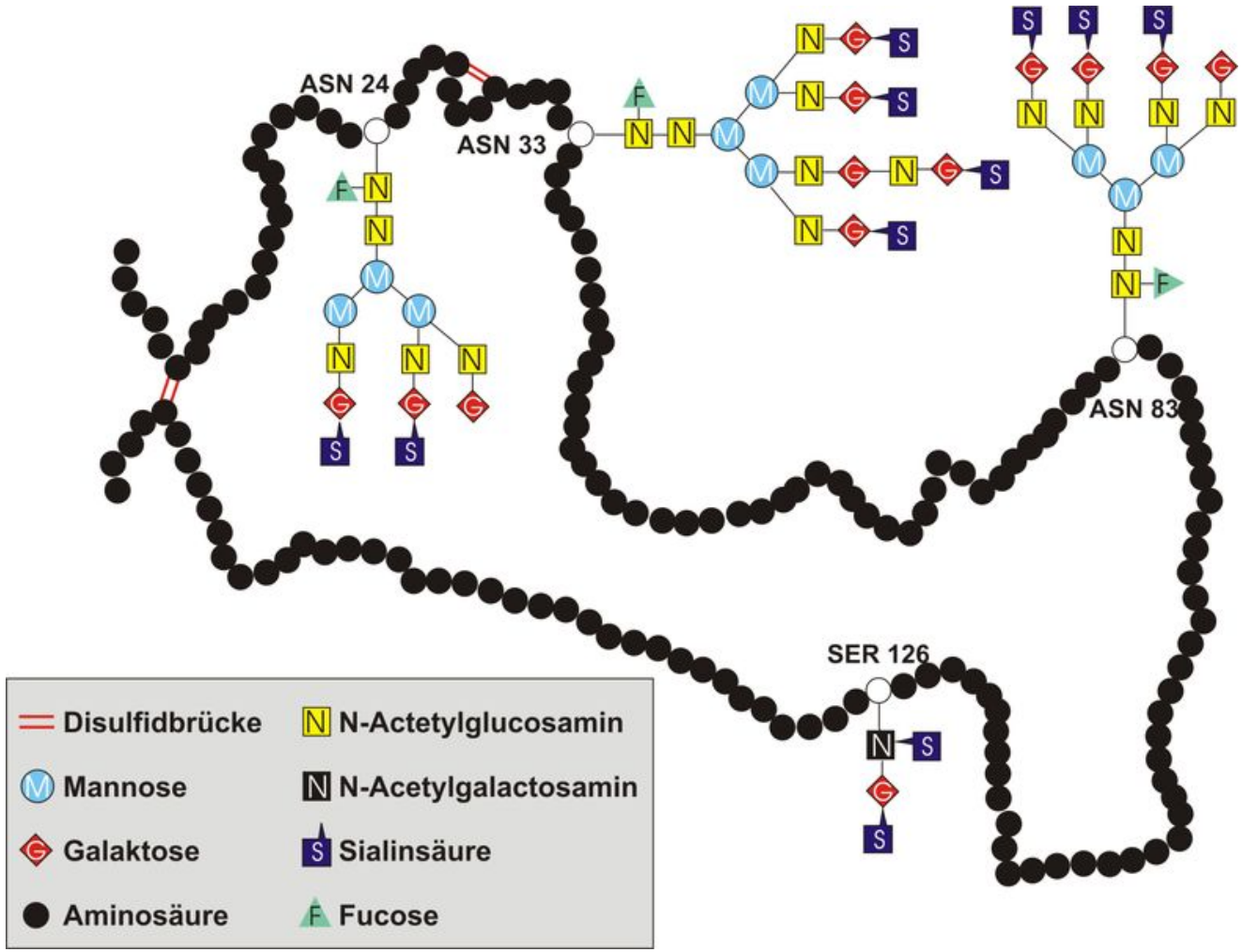
NOVARTIS

Pharma sales



2005 Total: 565 Bio $

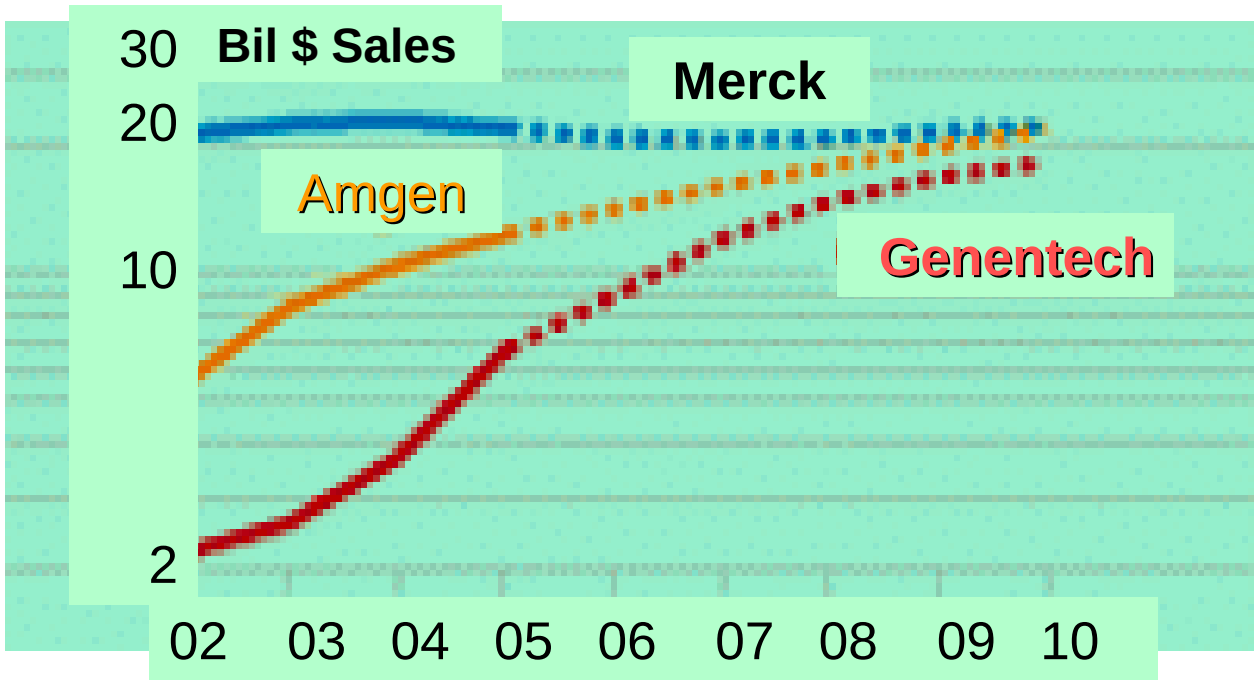
	2002	2003 [%]	2004
N-Am	50,9	49	47,8
EU	25,4	25	27,8
Eur.		3	1,8
Japan	11.7	11	11,1
As..	7,9	8	7,7
L-Am	4,1	4,0	3,8
Total Bio $	423,5	466,3	518,0



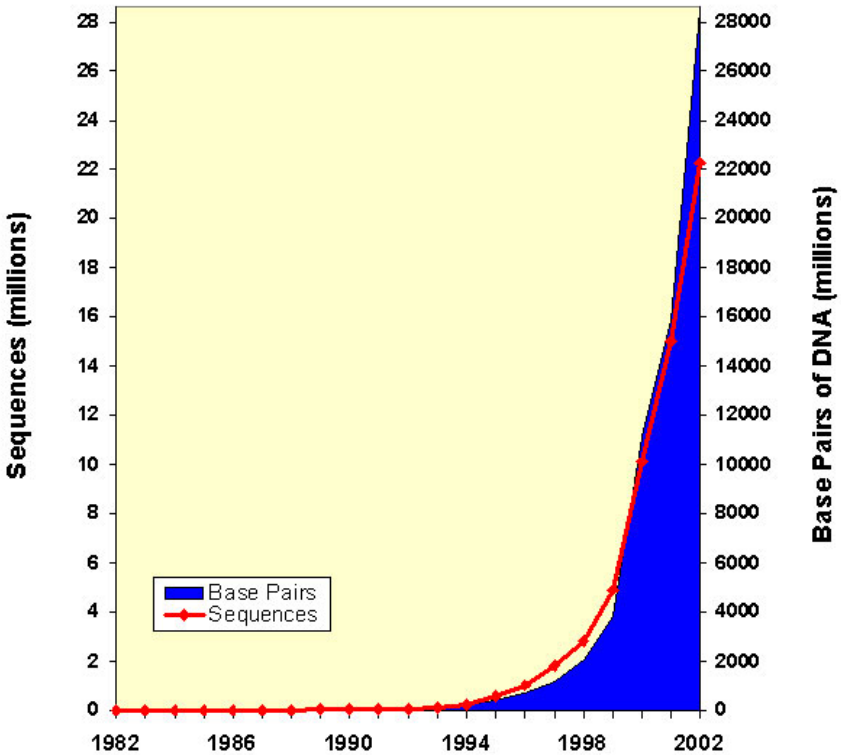
Sketch of the structure of erythropoetin

Synthetic Drugs - Biotech

Merck used to be America's biggest drug company by sales. But analysts' projections say **Amgen** and **Genentech** are catching up.



Sources: Reuters Fundamentals via FactSet Research Systems; Prudential Equity Group; Sanford C. Bernstein.



Source: NCBI

Fully sequenced genomes

- *Organisms* 751 projects

153 complete (16 A, 118 B, 19 E)

(*Eukarya* examples: mosquito (pest, malaria), sea squirt, mouse, yeast, homo sapiens, arabidopsis, fly, worm, …)

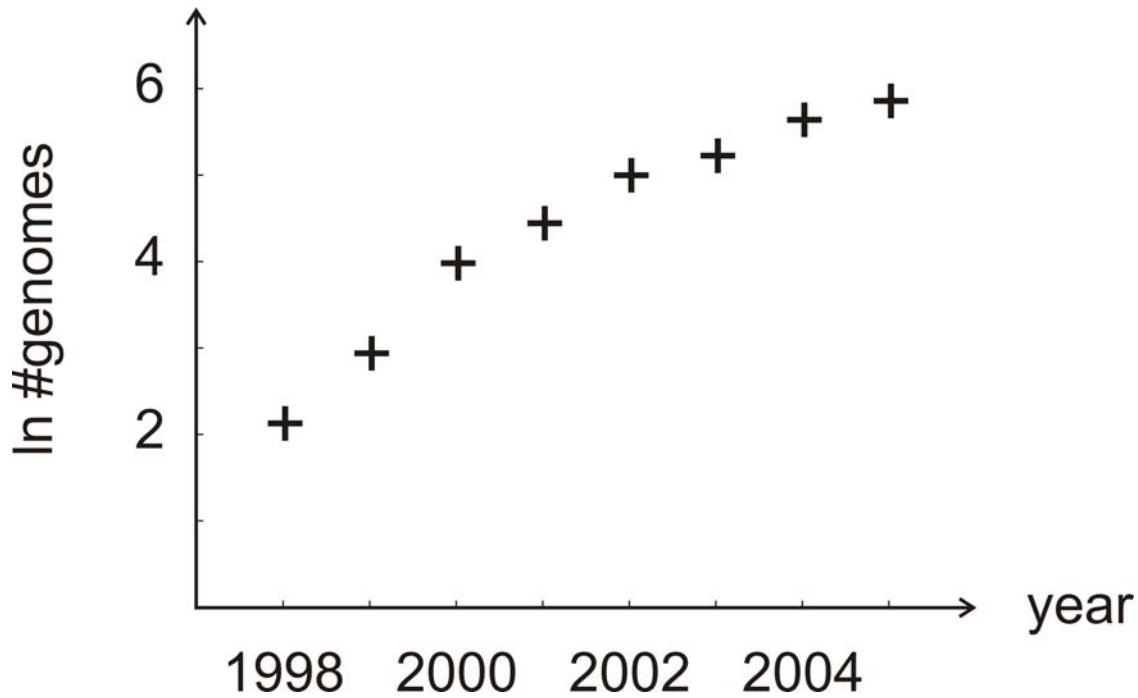
598 ongoing (23 A, 332 B, 243 E)

(*Eukarya* examples: chimpanzee, turkey, chicken, ape, corn, potato, rice, banana, tomato, cotton, coffee, soybean, pig, rat, cat, sheep, horse, kangaroo, dog, cow, bee, salmon, fugu, frog, …)

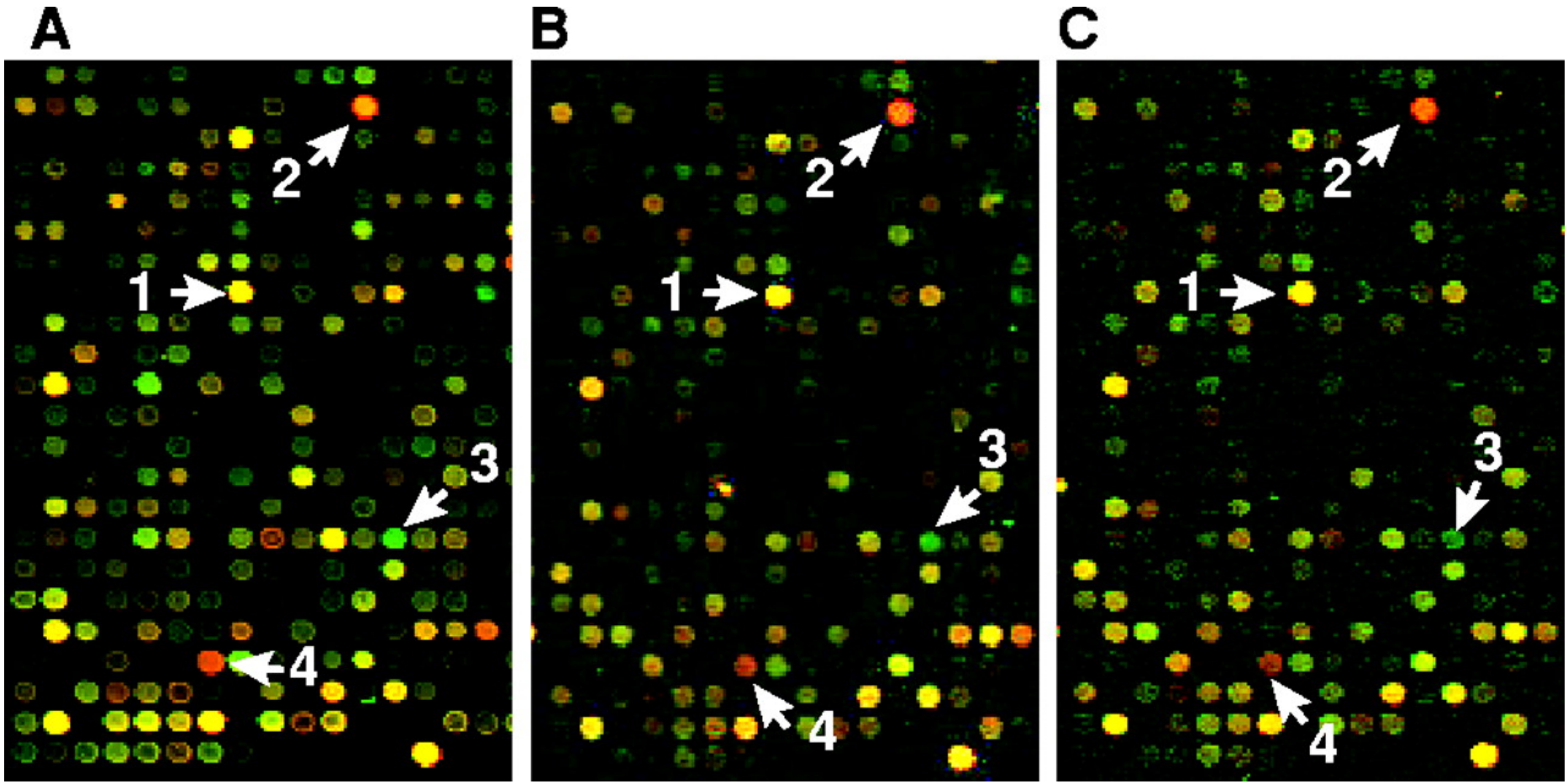
- *Other structures with genetic information*

68 phages
1328 viruses
35 viroids
472 organelles (423 mitochondria, 32 plastids, 14 plasmids, 3 nucleomorphs)

Source: Integrated Genomics, Inc.
August 12th, 2003



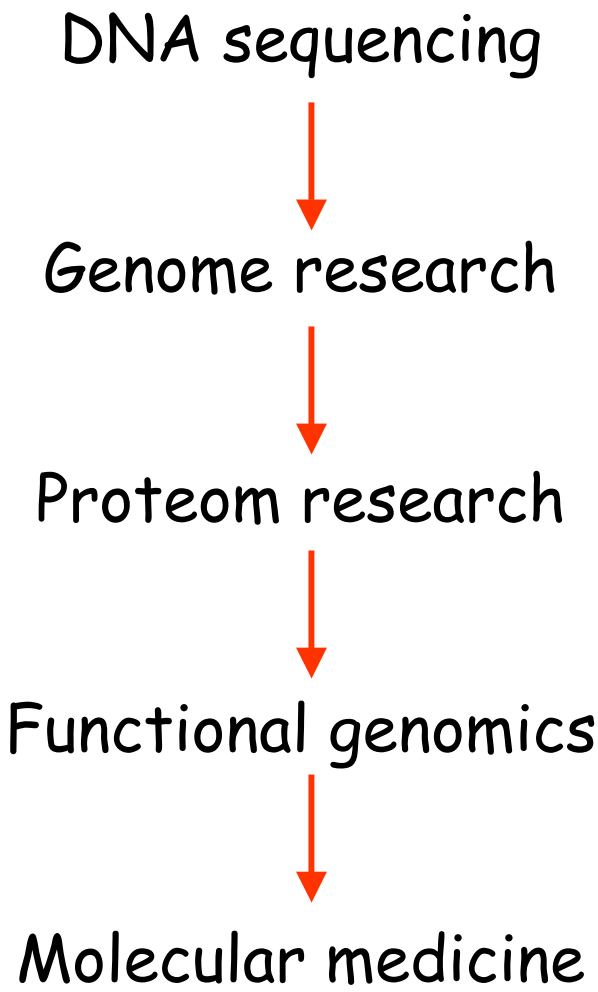
M.L. Riley, T. Schmidt, C. Wagner, H.-W. Mewes, D. Frishman.
Nucleic Acids Res. 33:D308-D310 (2005)



The same section of the microarray is shown in three independent hybridizations. Marked spots refer to: (1) protein disulfide isomerase related protein P5, (2) IL-8 precursor, (3) EST AA057170, and (4) vascular endothelial growth factor

Gene expression DNA microarray representing 8613 human genes used to study transcription in the response of human fibroblasts to serum

V.R.Iyer *et al.*, *Science* **283**: 83-87, 1999


DNA sequencing
Genome research
Proteom research
Functional genomics
Molecular medicine

Web-Page for further information:

http://www.tbi.univie.ac.at/~pks