



Sessão Temática 1 - MR

A IMPORTÂNCIA DA PESQUISA E DA INOVAÇÃO PARA A SUSTENTABILIDADE DA INDÚSTRIA QUÍMICA E FARMACÊUTICA



Eliezer J. Barreiro

Professor Titular



Coordenador



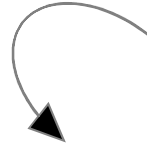
Química
e
Medicinal

www.farmacia.ufrj.br/lasbio / www.inct-inofar.ccs.ufrj.br

A pesquisa científica através dos tempos...



Galileo, Newton, Darwin, & Einstein



O físico Crick & e o biólogo Watson

JD Watson & FHC Crick, A Structure for Deoxyribose Nucleic Acid, *Nature* 1953, 171, 737-738 .



A equipe do genoma humano.

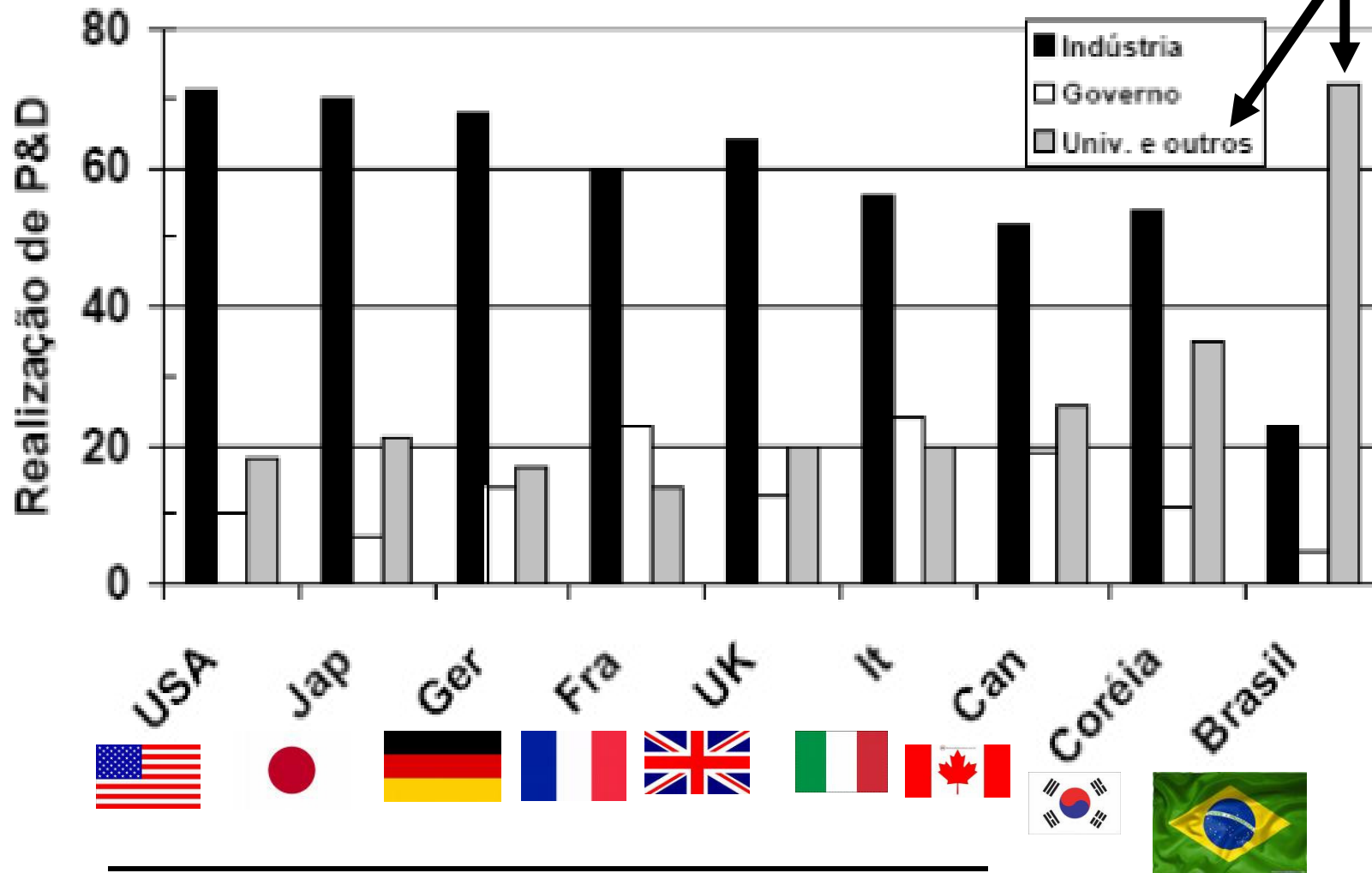


The Sequence of the Human Genome

J. Craig Venter, Mark D. Adams, Eugene W. Myers, Peter W. Li, Richard J. Mural, Granger G. Sutton, Hamilton O. Smith, Mark Yandell, Cheryl A. Evans, Robert A. Holt, Jeannine D. Gocayne, Peter Amanatides, Richard M. Ballew, Daniel H. Huson, Jennifer Russo Wortman, Qing Zhang, Chinnappa D. Kodira, Xiangqun H. Zheng, Lin Chen, Marian Skupski, Gangadharan Subramanian, Paul D. Thomas, Jinghui Zhang, George L. Gabor Miklos, Catherine Nelson, Samuel Broder, Andrew G. Clark, Joe Nadeau, Victor A. McKusick, Norton Zinder, Arnold J. Levine, Richard J. Roberts, Mel Simon, Carolyn Slayman, Michael Hunkapiller, Randall Bolanos, Arthur Delcher, Ian Dew, Daniel Fasulo, Michael Flanigan, Liliana Florea, Aaron Halpern, Sridhar Hannenhalli, Saul Kravitz, Samuel Levy, Clark Mobarry, Knut Reinert, Karin Remington, Jane Abu-Threideh, Ellen Beasley, Kendra Biddick, Vivien Bonazzi, Rhonda Brandon, Michele Cargill, Ishwar Chandramouliswaran, Rosane Charlab, Kabir Chaturvedi, Zuoming Deng, Valentina Di Francesco, Patrick Dunn, Karen Eilbeck, Carlos Evangelista, Andrei E. Gabrielian, Weiniu Gan, Wangmao Ge, Fangcheng Gong, Zhiping Gu, Ping Guan, Thomas J. Heiman, Maureen E. Higgins, Rui-Ru Ji, Zhaoxi Ke, Karen A. Ketchum, Zhongwu Lai, Yiding Lei, Zhenya Li, Jiayin Li, Yong Liang, Xiaoying Lin, Fu Lu, Gennady V. Merkulov, Natalia Milshina, Helen M. Moore, Ashwinikumar K Naik, Vaibhav A. Narayan, Beena Neelam, Deborah Nusskern, Douglas B. Rusch, Steven Salzberg, Wei Shao, Bixiong Shue, Jingtao Sun, Zhen Yuan Wang, Aihui Wang, Xin Wang, Jian Wang, Ming-Hui Wei, Ron Wides, Chunlin Xiao, Chunhua Yan, Alison Yao, Jane Ye, Ming Zhan, Weiqing Zhang, Hongyu Zhang, Qi Zhao, Liansheng Zheng, Fei Zhong, Wenyan Zhong, Shiaoping C. Zhu, Shaying Zhao, Dennis Gilbert, Suzanna Baumhueter, Gene Spier, Christine Carter, Anibal Cravchik, Trevor Woodage, Feroze Ali, Huijin An, Aderonke Awe, Danita Baldwin, Holly Baden, Mary Barnstead, Ian Barrow, Karen Beeson, Dana Busam, Amy Carver, Angela Center, Ming Lai Cheng, Liz Curry, Steve Danaher, Lionel Davenport, Raymond Desilets, Susanne Dietz, Kristina Dodson, Lisa Doup, Steven Ferreira, Neha Garg, Andres Gluecksmann, Brit Hart, Jason Haynes, Charles Haynes, Cheryl Heiner, Suzanne Hladun, Damon Hostin, Jarrett Houck, Timothy Howland, Chinyere Ibegwam, Jeffery Johnson, Francis Kalush, Lesley Kline, Shashi Koduru, Amy Love, Felecia Mann, David May, Steven McCawley, Tina McIntosh, Ivy McMullen, Mee Moy, Linda Moy, Brian Murphy, Keith Nelson, Cynthia Pfannkoch, Eric Pratts, Vinita Puri, Hina Qureshi, Matthew Reardon, Robert Rodriguez, Yu-Hui Rogers, Deanna Romblad, Bob Ruhfel, Richard Scott, Cynthia Sitter, Michelle Smallwood, Erin Stewart, Renee Strong, Ellen Suh, Reginald Thomas, Ni Ni Tint, Sukyee Tse, Claire Vech, Gary Wang, Jeremy Wetter, Sherita Williams, Monica Williams, Sandra Windsor, Emily Winn-Deen, Keriellen Wolfe, Jayshree Zaveri, Karena Zaveri, Josep F. Abril, Roderic Guigó, Michael J. Campbell, Kimmen V. Sjolander, Brian Karlak, Anish Kejariwal, Huaiyu Mi, Betty Lazareva, Thomas Hatton, Apurva Narechania, Karen Diemer, Anushya Muruganujan, Nan Guo, Shinji Sato, Vineet Bafna, Sorin Istrail, Ross Lippert, Russell Schwartz, Brian Walenz, Shibu Yooseph, David Allen, Anand Basu, James Baxendale, Louis Blick, Marcelo Caminha, John Carnes-Stine, Parris Caulk, Yen-Hui Chiang, My Coyne, Carl Dahlke, Anne Deslattes Mays, Maria Dombroski, Michael Donnelly, Dale Ely, Shiva Esparham, Carl Fosler, Harold Gire, Stephen Glanowski, Kenneth Glasser, Anna Glodek, Mark Gorokhov, Ken Graham, Barry Gropman, Michael Harris, Jeremy Heil, Scott Henderson, Jeffrey Hoover, Donald Jennings, Catherine Jordan, James Jordan, John Kasha, Leonid Kagan, Cheryl Kraft, Alexander Levitsky, Mark Lewis, Xiangjun Liu, John Lopez, Daniel Ma, William Majoros, Joe McDaniel, Sean Murphy, Matthew Newman, Trung Nguyen, Ngoc Nguyen, Marc Nodell, Sue Pan, Jim Peck, Marshall Peterson, William Rowe, Robert Sanders, John Scott, Michael Simpson, Thomas Smith, Arlan Sprague, Timothy Stockwell, Russell Turner, Eli Venter, Mei Wang, Meiyuan Wen, David Wu, Mitchell Wu, Ashley Xia, Ali Zandieh, and Xiaohong Zhu

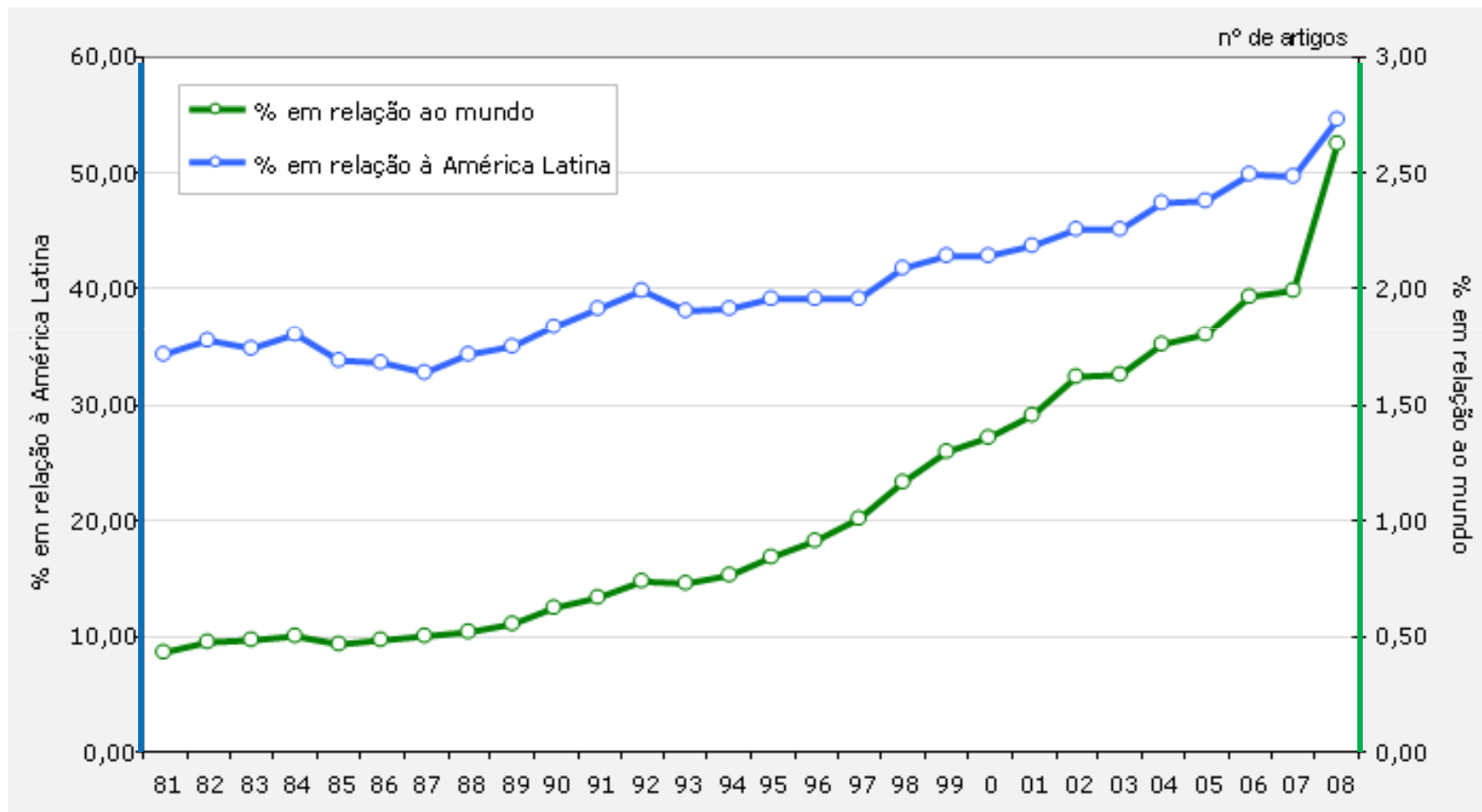


Aonde se faz pesquisa ?



Adaptado de C. H. Brito Cruz & C. A. Pacheco, "Conhecimento & Inovação: Desafios do Brasil no Século XXI", em www.inovacao.unicamp.br/report/intc-pacheco-brito.pdf (2/01/2009)

Artigos brasileiros publicados em periódicos científicos internacionais indexados na Thomson ISI, em relação à América Latina e ao Mundo, 1981-2008



A pesquisa científica brasileira têm ótima produtividade !



1209

Un Cambridge
88 Nobel



1892

Un Chicago
87 Nobel



1754

Un Columbia
79 Nobel



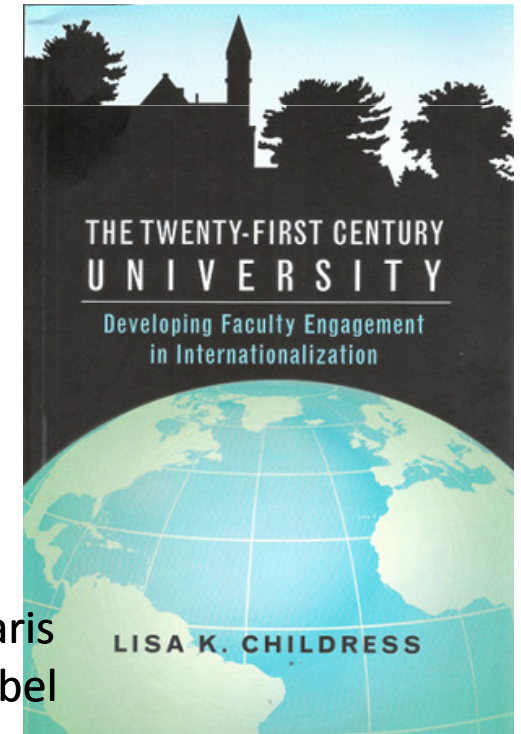
1861

MIT
78 Nobel



1891

Un Stanford
54 Nobel



THE TWENTY-FIRST CENTURY
UNIVERSITY
Developing Faculty Engagement
in Internationalization

LISA K. CHILDRESS

Un Harvard
47 Nobel



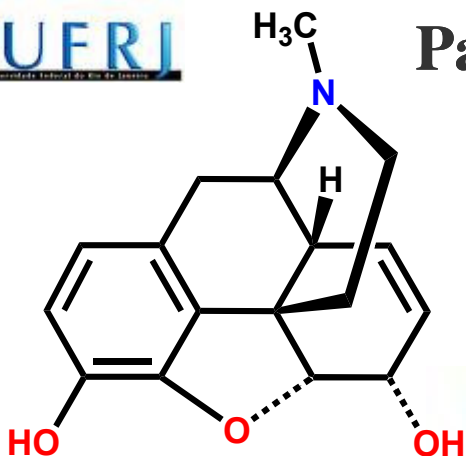
1636



1150

Un Paris
47 Nobel

The George Washington University



1947

Robert Robinson

1945

Alexander Fleming

1945

Howard W. Florey

1945

Ernest B Chain

Dorothy C Hodgkin
1965

William S Knowles

K Barry Sharpless 2001

Paul Ehrlich 1908

Emil Fischer

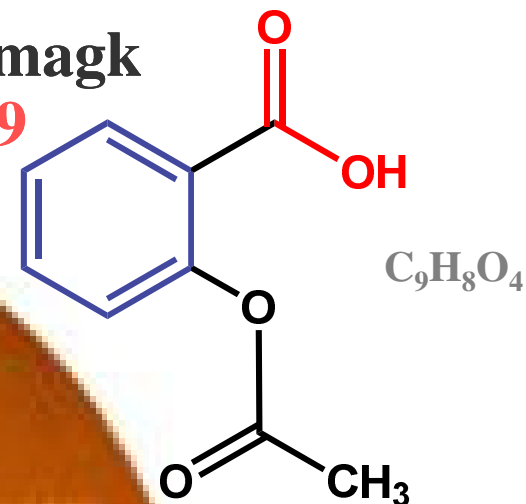
1902

Elias J Corey

1990

Gerhard Domagk

1939



John R Vane

1982

Bengt I Samuelsson

1982

Sune K Bergström

1982

Gertrude B Elion 1988

George Hitchings

1988

James W Black

Robert J. Lefkowitz

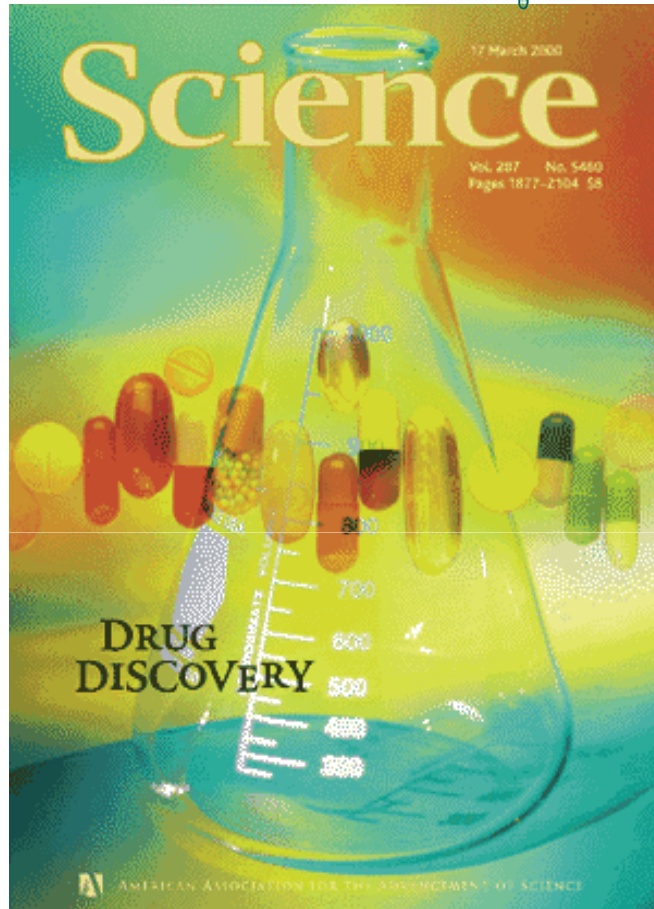
Brian K Kobilka

2012



Prêmio
Nobel

A invenção de fármacos ...



• *Science* **2000**, 287, 1951 (J.Uppenbrink & J.Mervis)

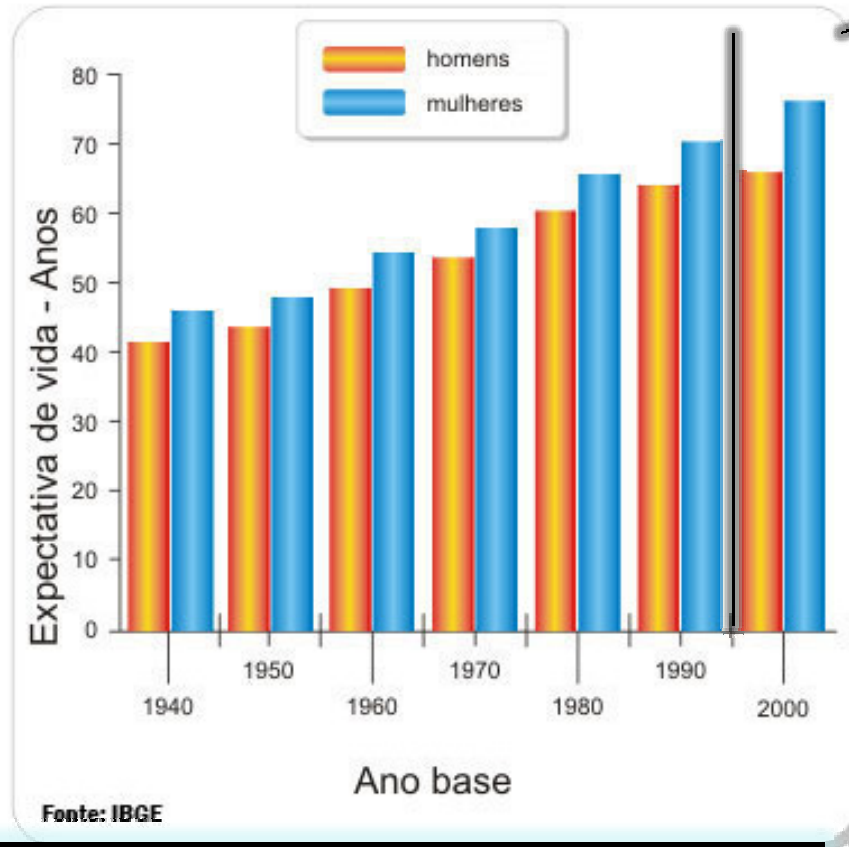
• *Science* **2004**, 303, 1713 (D. Kennedy)

...depende da pesquisa científica !

“Science is made of facts, just as houses are made of stones; but a mere collection of facts is no more science than a pile of stones a house” Henri Poincaré, 1902

Expectativa de vida

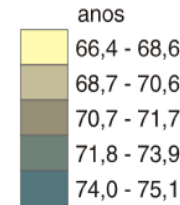
2010 – 73,5 anos (IBGE)



Fonte: IBGE

(<http://ibge.gov.br/>)

Expectativa de vida nos estados brasileiros 2007



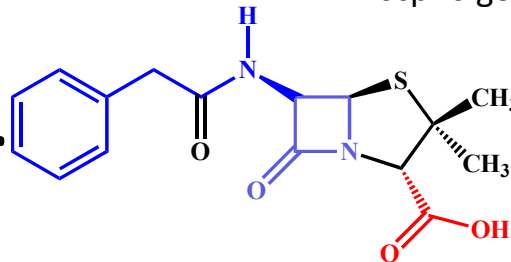
Fonte: IBGE - Síntese de Indicadores Sociais
Elaboração: SEPLAG/DEPLAN - 11/2008

0 750 1.500 km

www.scp.rs.gov.br/uploads/Expect_Brasil_07p.gif

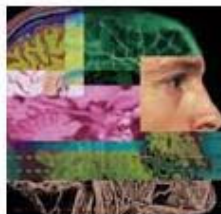


Os fármacos...



penicillin G

... salvam vidas !



the Pharmaceutical Century

TEN DECADES OF DRUG DISCOVERY

[Analytical Chemistry](#) | [Chemical & Engineering News](#) | [Modern Drug Discovery](#)
[Today's Chemist at Work](#) | [E-Mail Us](#) | [Electronic Readers Service](#)

1800s to 1919

We live today in a world of drugs. Drugs for pain, drugs for disease, drugs for allergies, drugs for pleasure, and drugs for mental health. Drugs that have been rationally designed; drugs that have been synthesized in the factory or purified from nature. Drugs fermented and drugs engineered. Drugs that have been clinically tested. Effective. Safe.



zoom

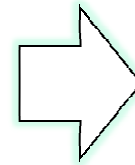


"We live today in a world of **drugs**. Drugs for **pain**, drugs for **disease**, drugs for **allergies**, drugs for **pleasure**, and drugs for **mental health**. Drugs that have been **rationally designed**; drugs that **have been synthesized** or **purified from nature**. Drugs **fermented** and drugs **engineered**. Drugs that have been clinically tested. Effective. Safe."

Ecônomoia do conhecimento



Indústria farmacêutica



Fármaco

Capacidade tecnológica || Mercado

Propaganda

Propriedade intelectual

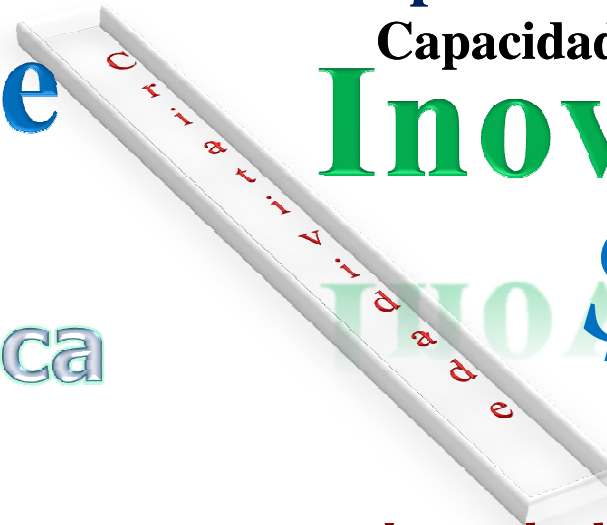
Capacidade industrial

Inovação

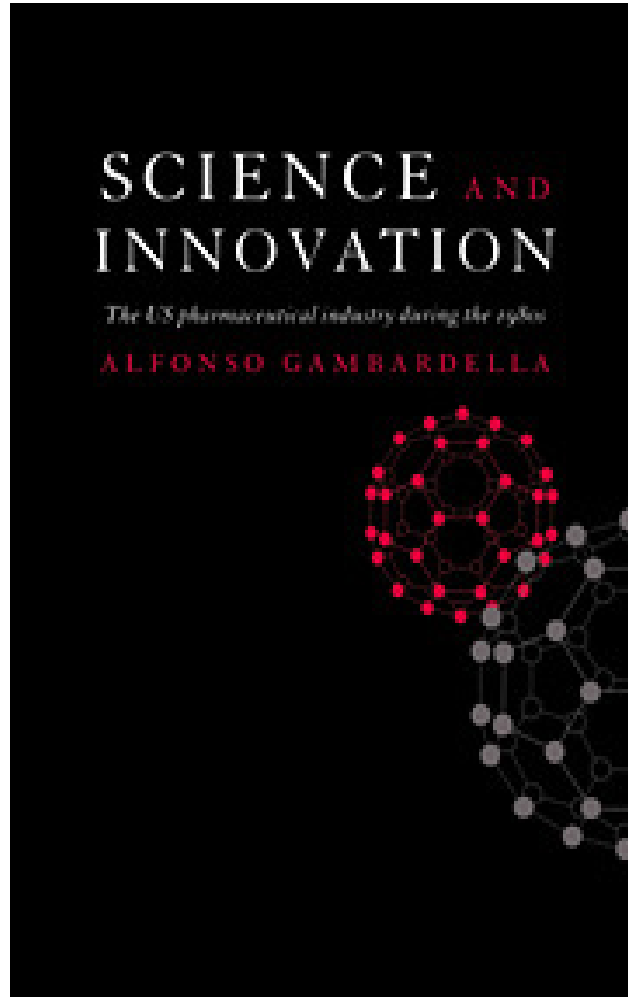


Universidade

Pesquisa científica



Postos de trabalho qualificados



A inovação tecnológica é um dos processos mais dinâmicos da atividade industrial. Este dinamismo se expressa de forma acentuada na inovação farmacêutica que, mais do que qualquer outra, depende da efetiva interação entre Ciência & Tecnologia.



Inovação ?

Inovações terapêuticas

propranolol

cimetidina

captopril

celecoxibe

simvastatina

indinavir

imatinibe

losartana

maraviroque

sildenafil

Química
e Farmacologia
Medicinal





Raymond Ahlquist (1914)

A STUDY OF THE ADRENOTROPIC RECEPTORS

RAYMOND P. AHLQUIST

From the Department of Pharmacology, University of Georgia School of Medicine

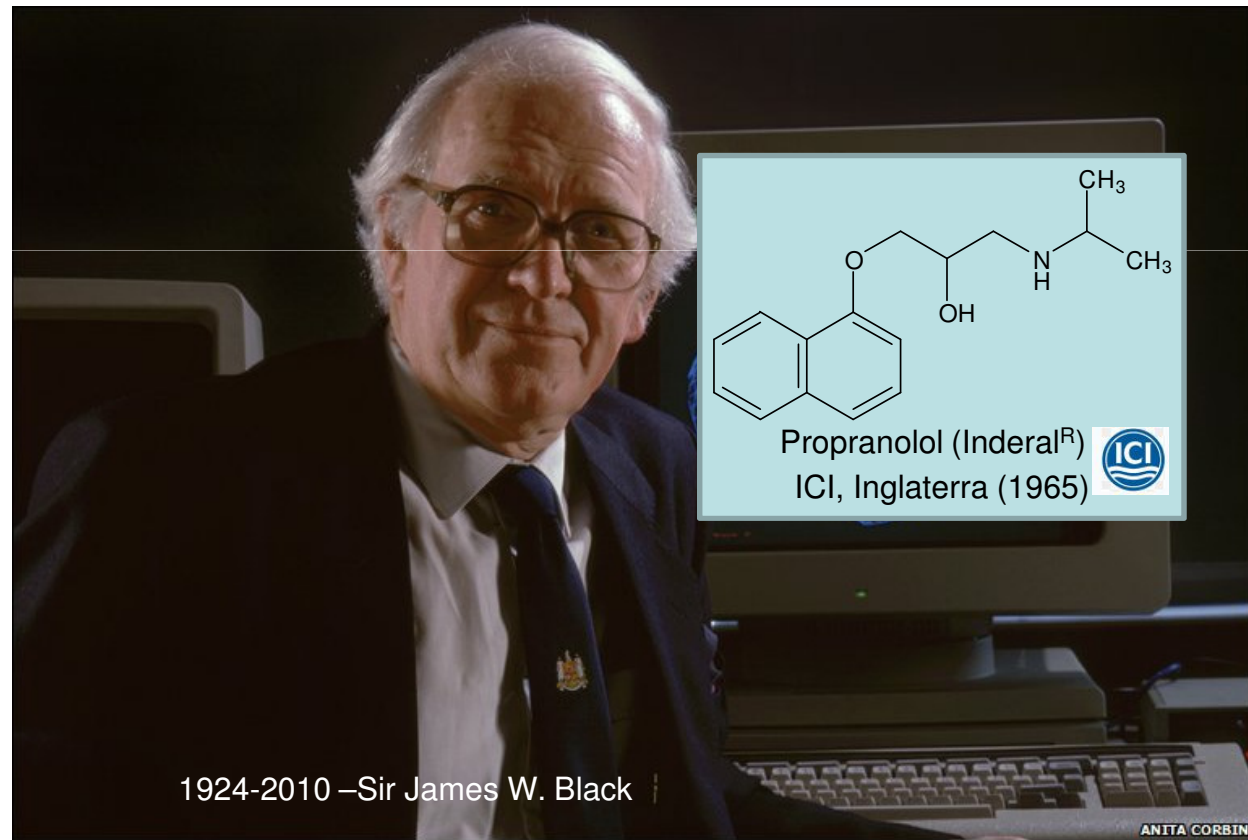
AUGUSTA, GEORGIA



1905 – Henry Dale



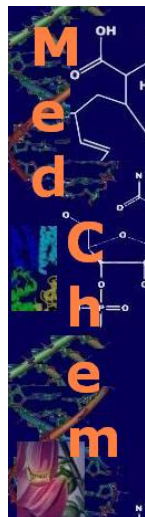
**Premio Nobel
1988**



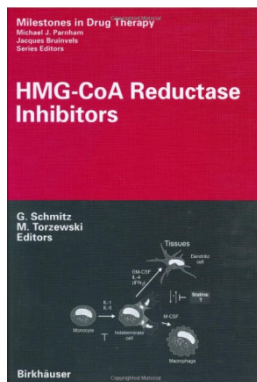
Atorvastatina

Estatinas

Top \$elling
drug in hi\$tory



1985 - Bruce Roth



Premio Nobel
1985



JL Goldstein MS Brown



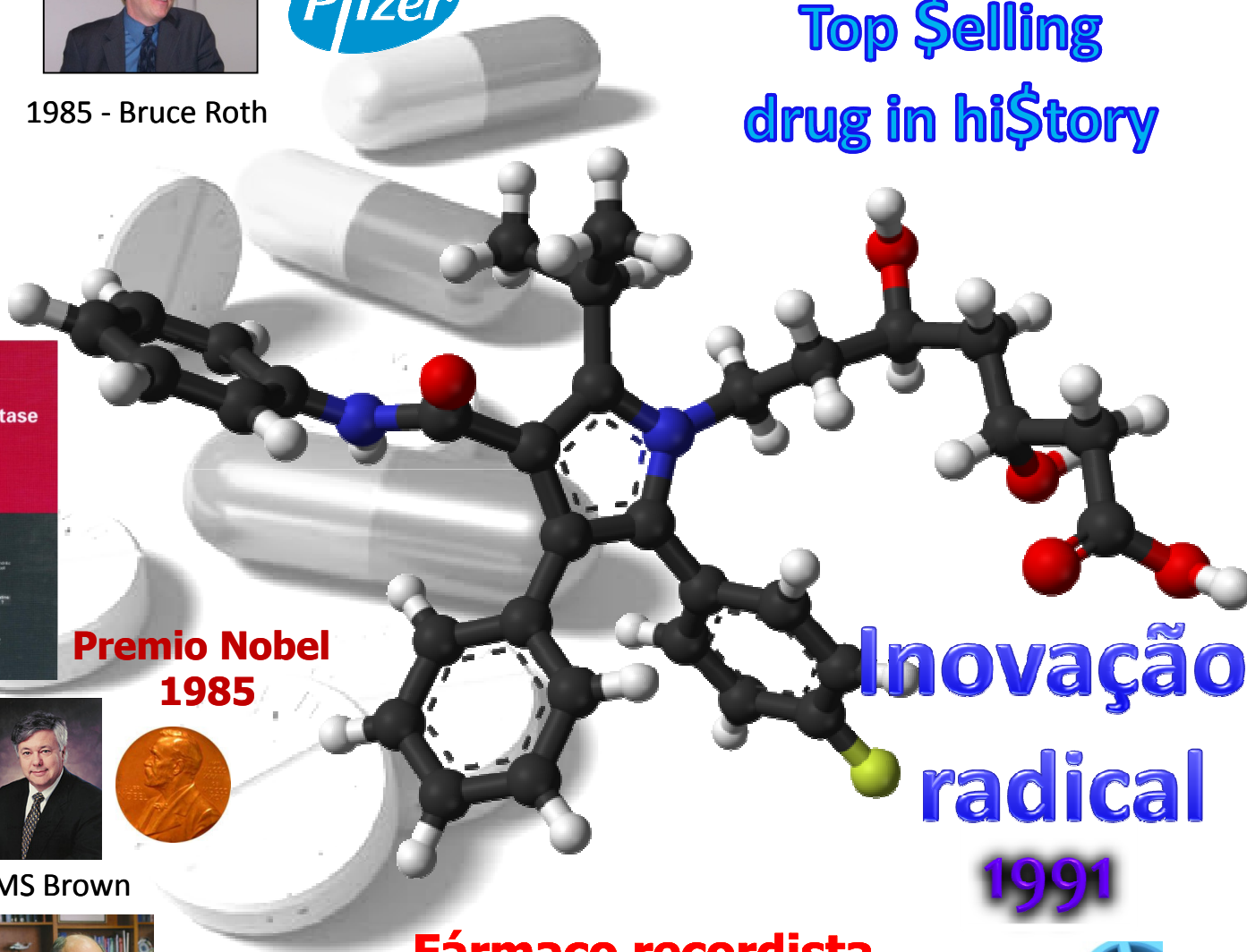
A Endo AA Patchett



Fármaco recordista
mundial em vendas:
US\$ 150 bilhões



Inovação
radical
1991



Total de vendas do Lipitor^R (atorvastatina, Pfizer)

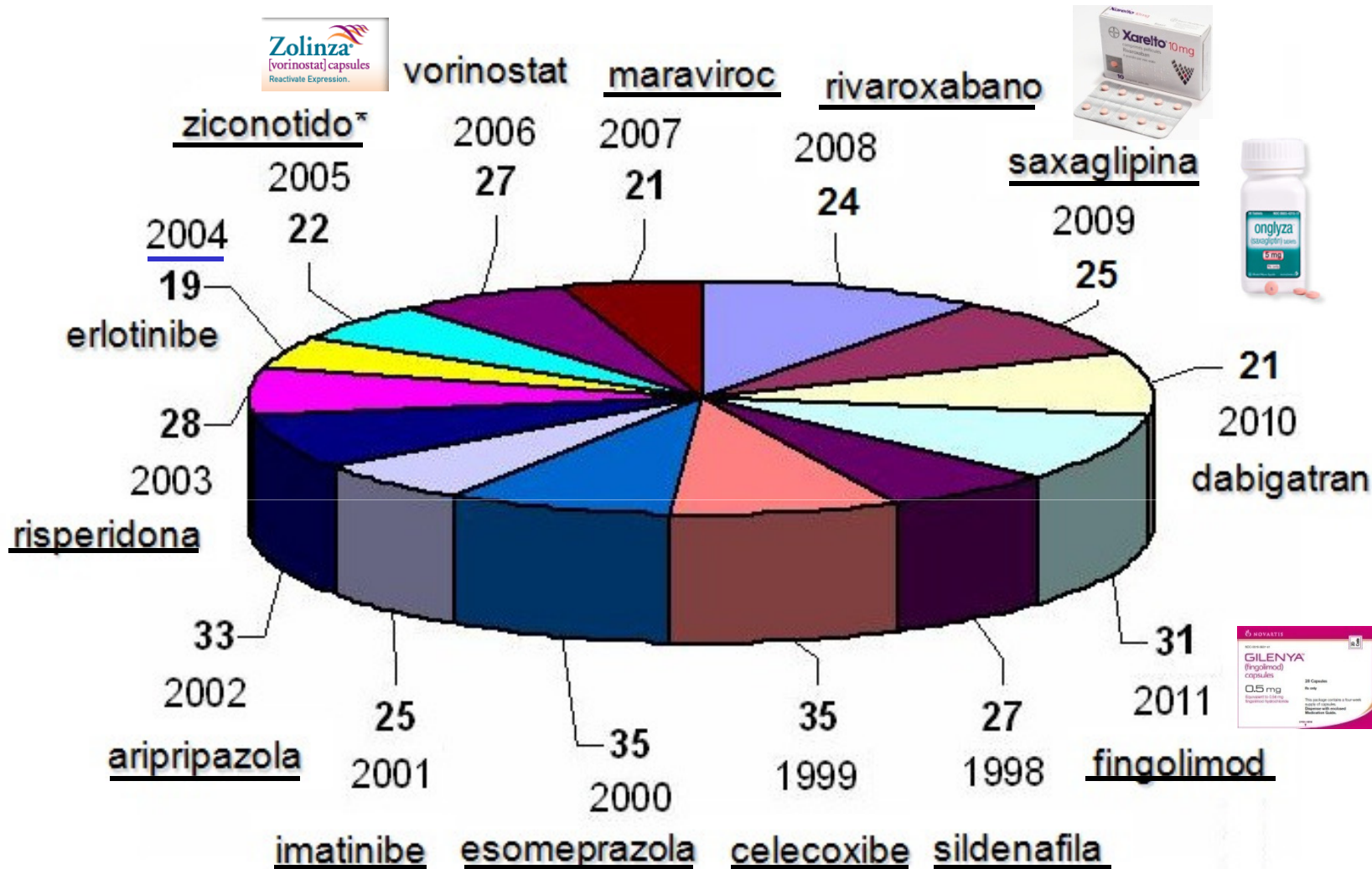
ANO DE VENDAS	EM BILHÕES (US)
2001	7,0
2002	8,6
2003	10,3
2004	12,0
2005	12,8
2006	13,0
2007	13,5
2008	13,8
2009	13,3
2010	13,3
2011*	12,2
Total	119,2



1991-2000 = ca. US\$ 50 bi

* Em novembro de 2011 expirou a patente nos EUA

Novos fármacos lançados por ano / 1998-2011



Inovações terapêuticas

The Big-Pharma productivity crisis

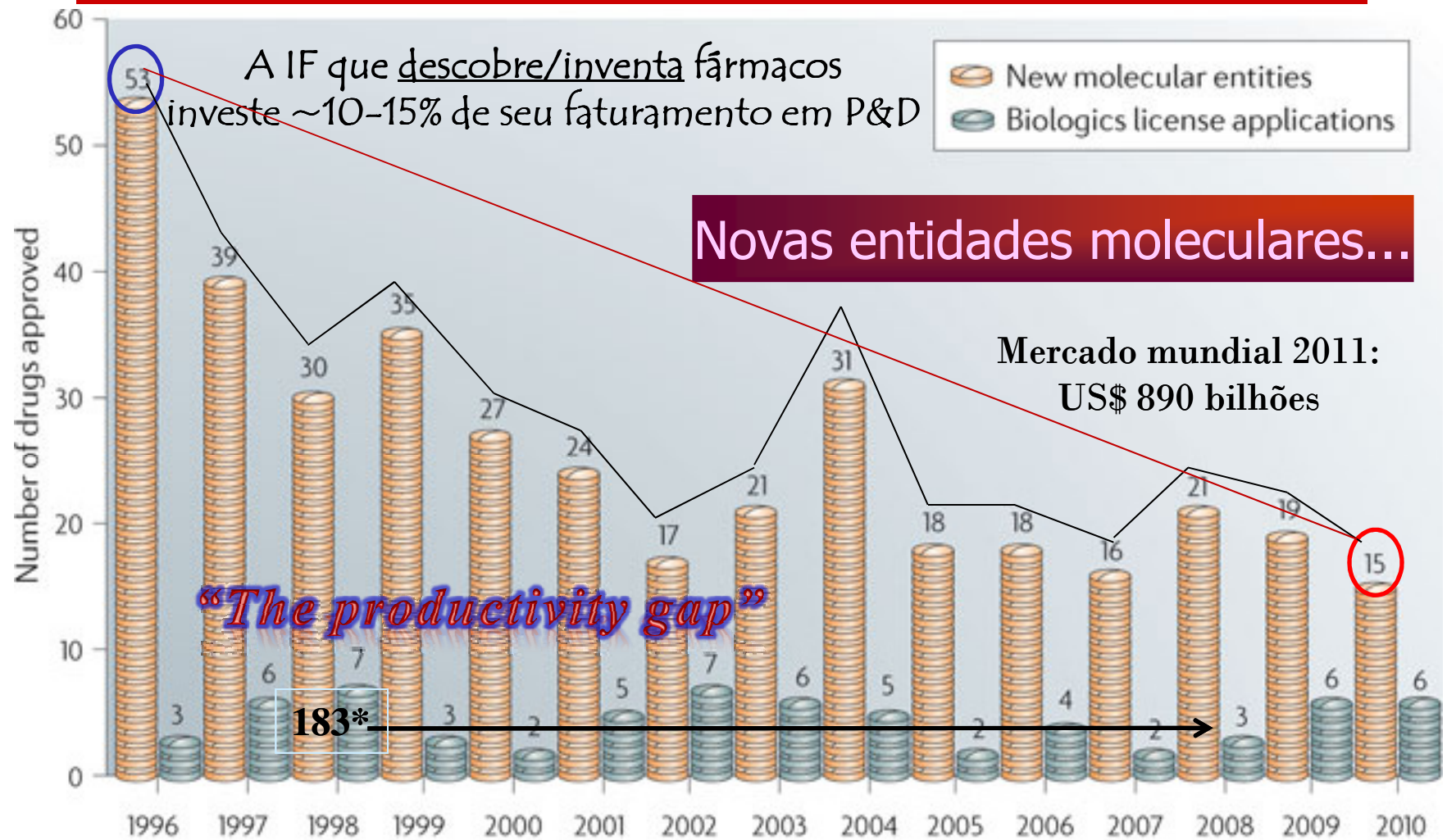
A Mullard, *Nature Rev. Drug Discov.* **2011**, *10*, 82

P Pammolli, L Magazzini, M Riccaboni, *Nature Rev. Drug Discov.* **2011**, *10*, 428

D Swinney & J Anthony, *Nature Rev. Drug Discov.* **2011**, *10*, 507



A crise de inovação na Bigpharma



A. Mullard, 2010 FDA drug approvals, *Nature Rev. Drug Discov.* **2011**, *10*, 82 (doi: 10.1038/nrd3370)

Nature Reviews | Drug Discovery



* D Swinney & J Anthony, *Nature Rev. Drug Discov.* **2011**, *10*, 507

O processo da descoberta de fármacos...

IN FOCUS NEWS



2011

PHARMACEUTICALS

Traditional drug-discovery model ripe for reform

Academic researchers set to play much greater role in pharmaceutical development.

BY DANIEL CRESSEY

With drug pipelines running dry and a slew of blockbuster medicines about to lose patent protection, the voices arguing that the traditional drug-development process is too expensive and inefficient to survive are getting louder.

Employing thousands of in-house scientists to develop drug candidates from scratch has turned into a billion-dollar gamble that simply isn't delivering enough profitable products to market. Bernard Munos, founder of the Inno-Think pharmaceutical policy research group in Indianapolis, Indiana, is not alone in believing that the next three years "will probably see an implosion of the old model" of drug discovery.

So what comes next? Cutbacks, certainly: witness Pfizer's dramatic announcement early last month that it will soon close its research site at Sandwich, UK, and slice roughly US\$1.5 billion from its proposed 2012 research and development spend (see *Nature* 470, 154; 2011).



HULTON-DEUTSCH/COBBIS

The kit may have improved, but the in-house drug discovery model has changed relatively little.

Nature 2011, 471, 17

J Hunter & S Stephens, *Nature Rev. Drug Discov.* **2010**, *9*, 87



Is open innovation the way forward for big pharma?

therapeutic
innovation

The current, fully integrated business model of large pharmaceutical companies is increasingly considered to be unsustainable, and so new approaches that engage large and small companies, governments and academic institutions are needed. Could 'open innovation' models that have proved successful in other sectors be fruitfully adopted by the pharmaceutical industry?

OPEN INNOVATION
DRUG DISCOVERY

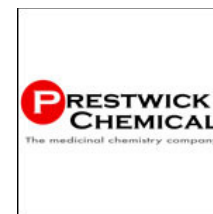
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New paradigms to innovative drugs, are been drawing!

AstraZeneca 

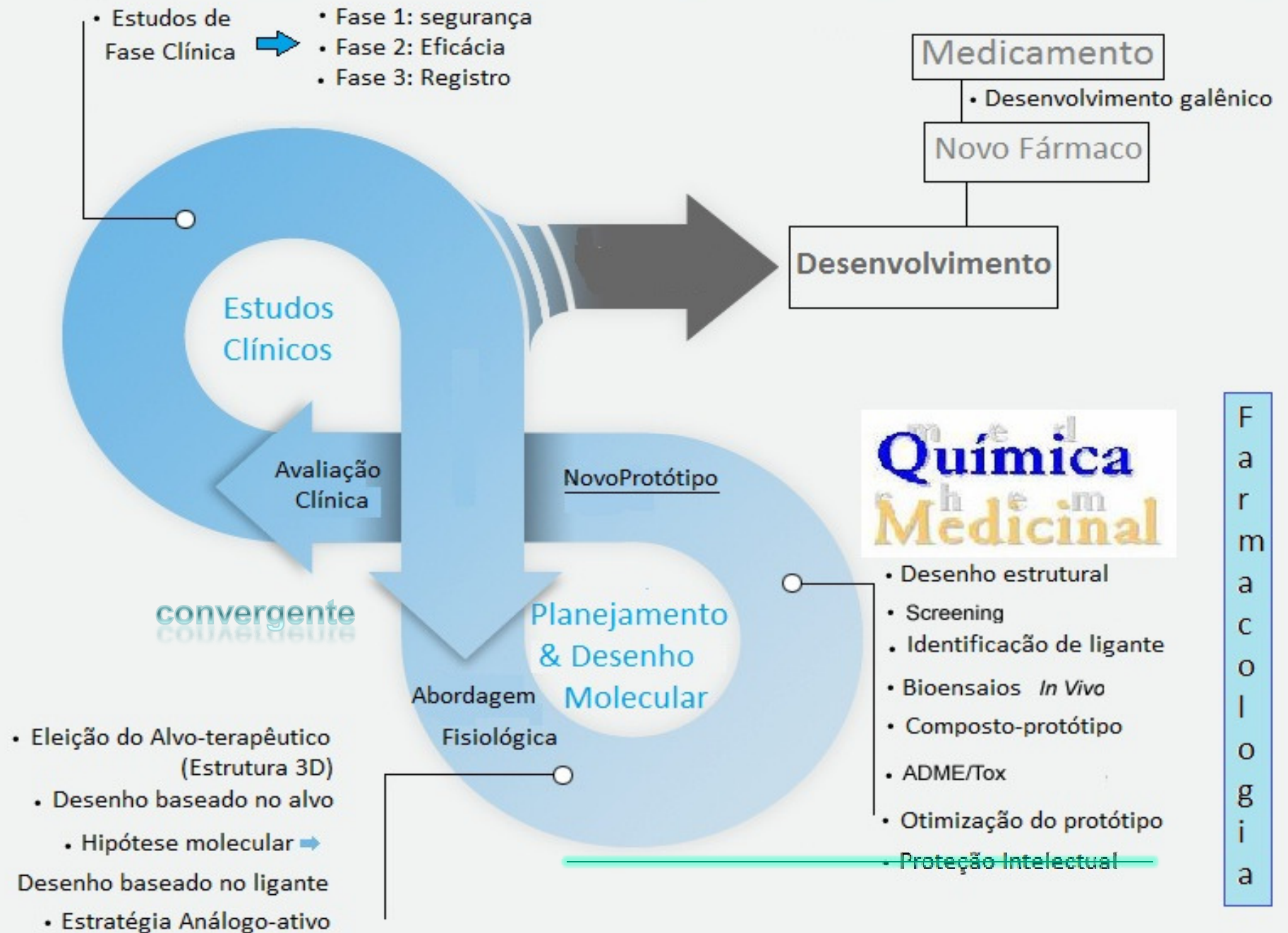


Tres Cantos Medicines
Development Campus

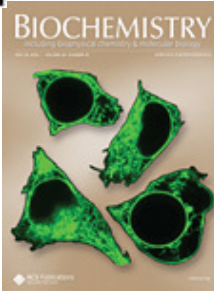


M Goldman, Reflections on the Innovative Medicines Initiative, *Nature Rev. Drug Discov.*, **10**, 321–322 (2011); F Pammolli *et al.*, The productivity crisis in pharmaceutical R&D, *Nature Rev. Drug Discov.*, **10**, 428 (2011); M R Barnes *et al.*, Lowering industry firewalls: pre-competitive informatics initiatives in drug discovery, *Nature Rev. Drug Discov.*, **8**, 701–708 (2009); B Hughes, Harnessing open innovation, *Nature Rev. Drug Discov.*, **8**, 344–345 (2009); B Munos, Can open-source R&D reinvigorate drug research? *Nature Rev. Drug Discov.* **5**, 723–729 (2006).

Ciclo do desenho e planejamento de novos fármacos e medicamentos



F
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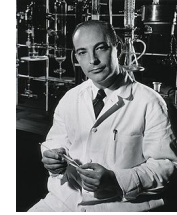
The Two Cultures: Chemistry and Biology¹

Arthur Kornberg

Department of Biochemistry, Stanford University, Stanford, California 94305

Received July 14, 1987

Prêmio Nobel, 1959



Arthur Kornberg
1918-2007

Much of life can be understood in rational terms if expressed in the language of chemistry. It is an international language, a language for all of time, and a language that explains where we came from, what we are, and where the physical world will allow us to go. Chemical language has great esthetic beauty and links the physical sciences to the biological sciences. Unfortunately, the full use of this language to understand life processes is hindered by a gulf that separates chemistry from biology.

¹ Adapted from a lecture at a meeting of the American Association for the Advancement of Science, Washington, DC, 1987.

Interdisciplinarity

“...the historical roots of

chemistry and biology

are intertwined in many places...

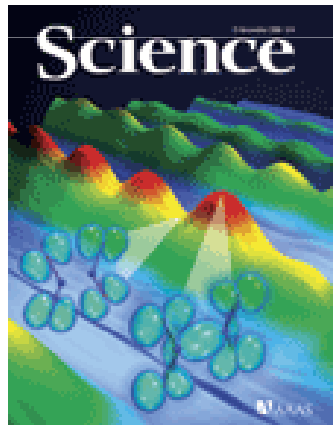
Pharmaceutical chemistry was until recently the bastion of organic chemistry... in the search for alternative or superior drugs for the treatment of various diseases...”



University of Stanford

Multi-University Research Teams: Shifting Impact, Geography, and Stratification in Science

Benjamin F. Jones,^{1,2*} Stefan Wuchty,^{3*} Brian Uzzi^{1,3,4*}

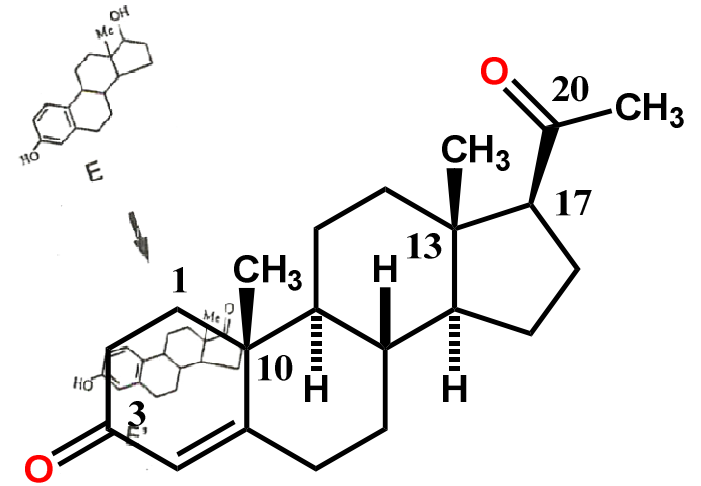
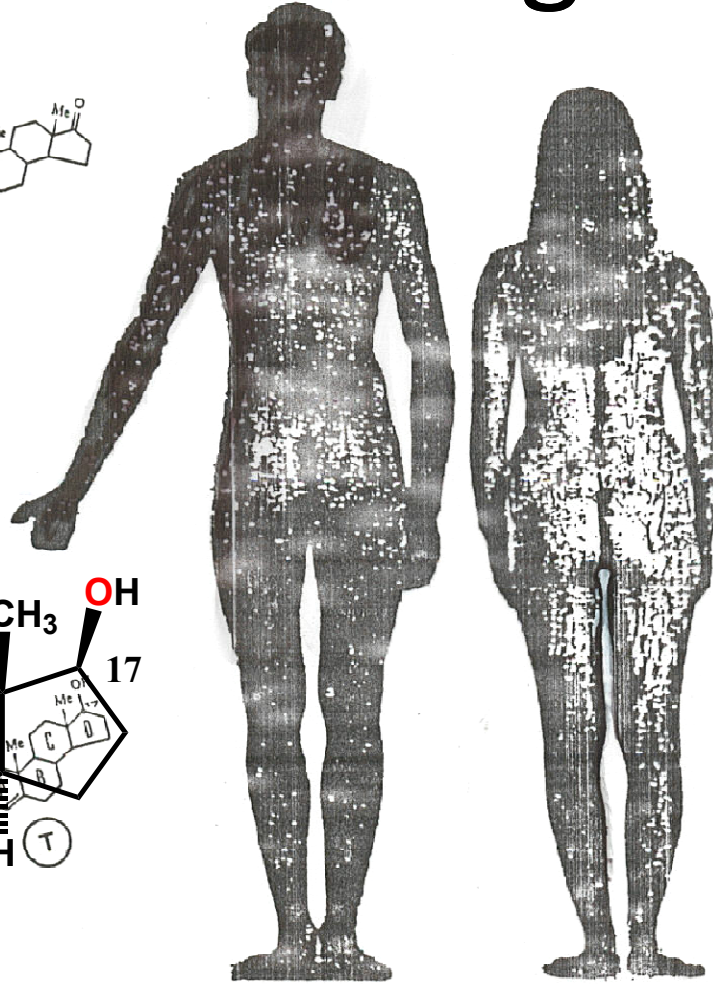
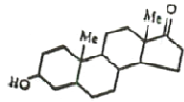


SCIENCE VOL 322 21 NOVEMBER 2008 1259

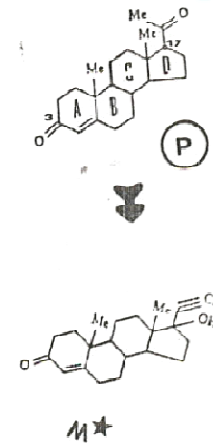
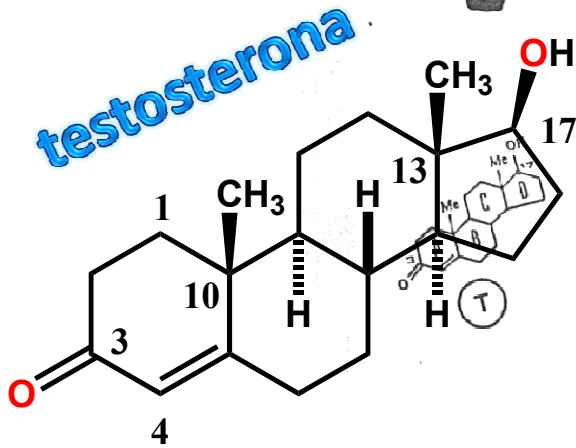
¹Kellogg School of Management, Northwestern University, Evanston, IL 60208, USA. ²National Bureau of Economic Research, Cambridge, MA 02138, USA. ³Northwestern Institute on Complexity (NICO), Northwestern University, Evanston, IL 60208, USA. ⁴Haas School of Business, University of California at Berkeley, Berkeley, CA 94720, USA.

.....
"Neste artigo os autores demonstram que o trabalho em equipe, em Ciência, cada vez mais amplia os limites da universidade, representando uma mudança na qualidade e na produtividade de conhecimento novo, em praticamente todos os campos"

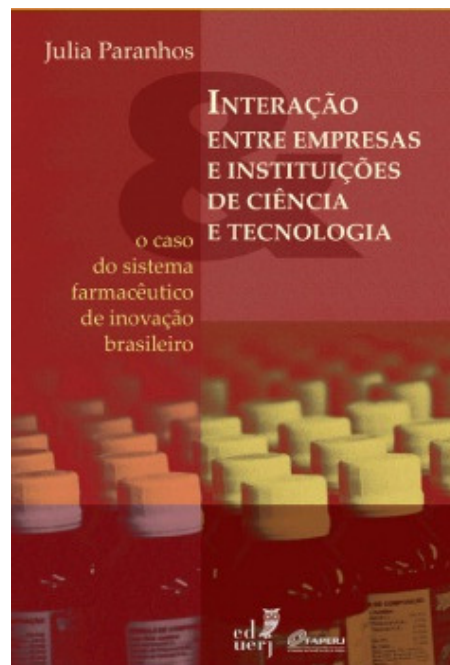
A complexidade do sistema biológico



progesterona



O exercício da interdisciplinaridade exige novos arranjos institucionais & temporais para a qualificação profissional adequada !



Há tendência em se implantarem nos currículos, modelos que são meras cópias do passado, nem sempre melhoradas, que reproduzem situações de certezas que não estimulam, a capacidade criativa dos estudantes, senão a atrofiam reduzindo seu potencial inovador.

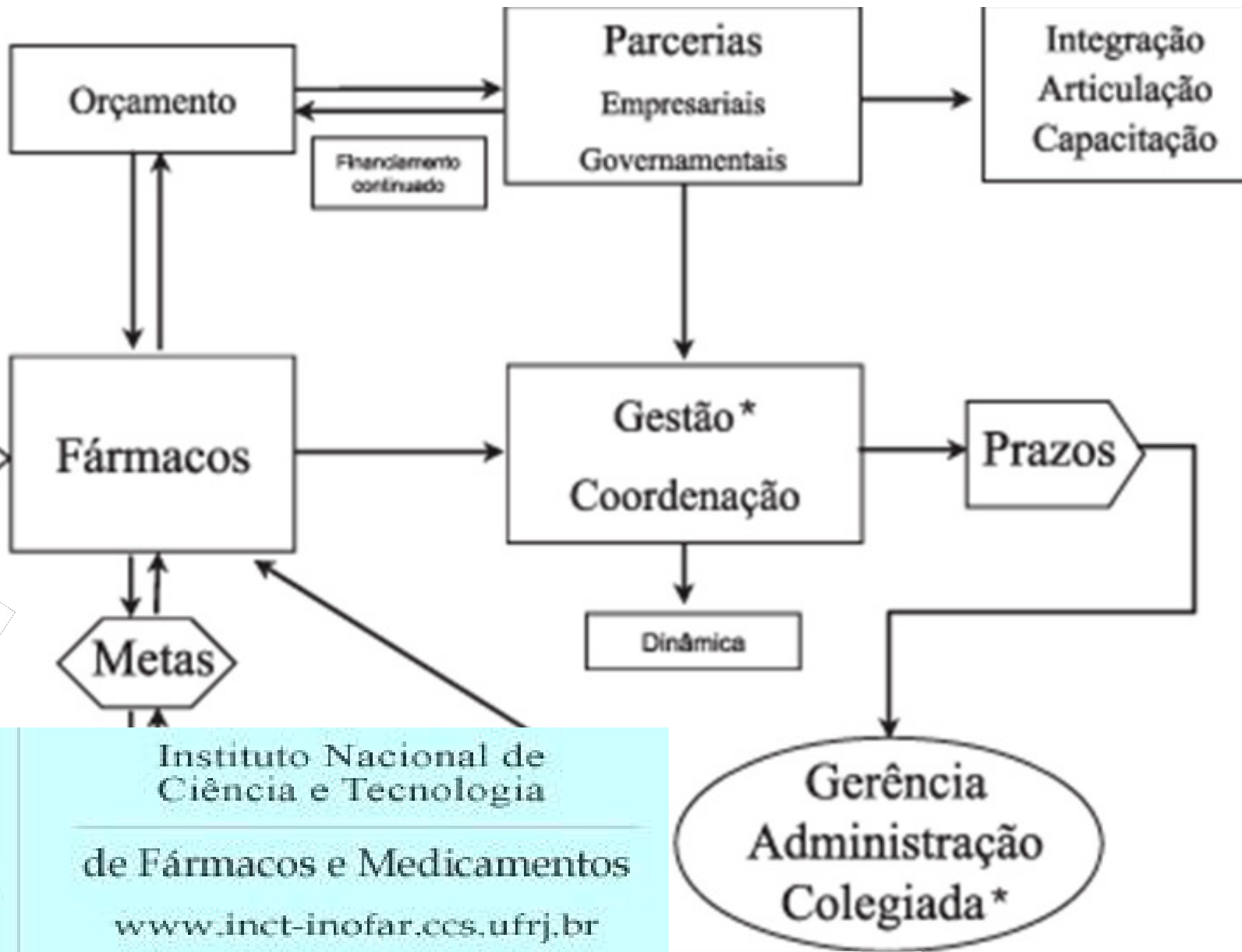
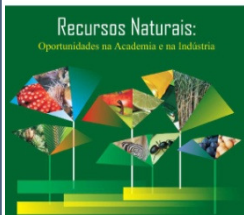


Horizonte temporal
X fronteira tradicional

Características da IF

- Tem intensa atividade de pesquisa (não no BR);
- O padrão de competitividade depende da capacidade de inovação (não no BR);
- Elevada capacidade de inovação radical >>>> incremental (no BR é o oposto);
- *ca. 8-12% do chiffre d'affaire* são investidos em P&DI (não no BR);
- Intensa atividade de PI (quase inexistente no BR);
- Força de trabalho em sua maioria qualificada

Interação efetiva e produtiva do setor empresarial farmacêutico com ICT's no Brasil é incipiente, superficial, episódica e ocasional !



EJ Barreiro & CAM Fraga, A questão da inovação em fármacos no Brasil: proposta de criação do programa nacional de fármacos (Pronfar), *Quim Nova (Supl.)* 2005, 28, S56-S63

Convite

<http://ejb-eliezer.blogspot.com>

De fármacos e suas descobertas

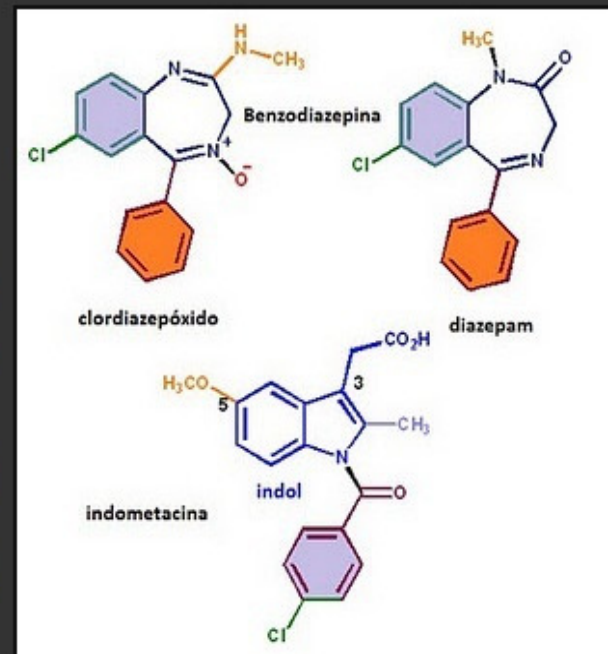
Pretende-se tratar de temas, opiniões, comentários sobre a Ciência dos Fármacos, seu uso seguro e benefícios. Aspectos da formação qualificada de universitários e pós-graduandos nas Ciências dos Fármacos também são de interesse.

SÁBADO, 26 DE NOVEMBRO DE 2011

A Linha do Tempo da Química Medicinal: assim nascem os fármacos (IV)



Nesta etapa da Linha do Tempo da Química Medicinal: assim nascem os fármacos atingimos a década de 50, a partir de quando surgiram inúmeras inovações terapêuticas significativas, resultado dos avanços importantes observados em várias disciplinas relacionadas à Química ou à Biologia.



<http://ejb-eliezer.blogspot.com>

Obrigado



www.farmacia.ufrj.br/lassbio
ejbarreiro@ccsdecania.ufrj.br
ejb-eliezer.blogspot.com.br

Uma das sete maravilhas do mundo moderno!