

CURRENT SCIENCE

Oct 10 2004

Drug Discovery: Myth and Reality

Volume 87 Number 7

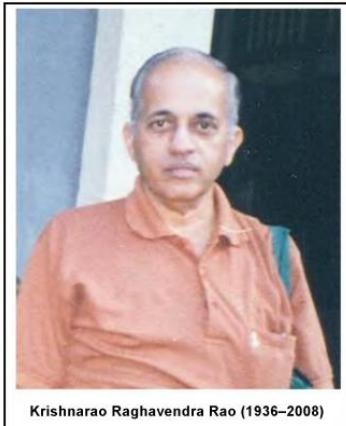
10 October 2004
EDITORIAL

An editor, passing an editorial column has a wonderful advantage: standing as obstacles before the referees and sub-editors do not stand as obstacles before the article is published. For a regular columnist, the most difficult task is to find a topic worth about: that comes the difficult task to find a topic of gathering, at least a spectre of smattering equity formitable summing and significantly more difficult, more time pointers. Committed, as I am, to writing a fortnightly col-

cine and erythromycin among them. Once 'leads' have been identified, the task of moving forward requires careful pharmacological and toxicological evaluation, before the clinical trials can begin. But, as the drug industry has matured, and as the process of discovering promising new molecules has become more difficult, more time pointers, have become more expensive.



S Ramaseshan (1923-2003)



Krishnarao Raghavendra Rao (1936-2008)



Riki Krishnan (1971-2010)

CURRENT SCIENCE

Oct 10 2011

Malaria: Recognising a Chinese Triumph

10 October 2011
EDITORIAL

Malaria: Malaria is a disease that has been with us for all of human history. Malaria parasites develop host to host, traces of disease, fashion, and transmit them from Francis Cox of the genus *Plasmodium* and their vectors (Cox, F. E. G., 1913). An estimated 250 million people are

420). While parasites rarely indeed very rarely, switch hosts, it is precisely this ability that has been advanced as an important adaptive trait of the parasite. While the 2333 *Plasmodium* species observed, their resilience, a major adaptability health issue, a major in the 21st century. An estimated 250 million people are

Volume 101 Number 7

Volume 99 Number 10

Chemicals, Chemistry and Molecules

10 October 2004
EDITORIAL

Judicial pronouncements have an air of finality. In India, we now turn to an overburdened judicial system to resolve failures of national issues in everyday life, ranging from major national issues to minor and often litigious controversies. Courts oversee investigations into an ever increasing number of scams and misdeeds, by those who have been charged with the responsibility to govern. If

steam not a chemical? When the Bombay High Court says so (Ritter, S. K., *Chem Eng News*, 2010, 88, 56) The court verdict, delivered in little general interest, except to those concerned with chemicals and the chemistry of chemistry, or resuming the uncertain world of journalism, the

25 November 2010
EDITORIAL

25 April 2013
EDITORIAL

CURRENT SCIENCE

Apr 25 2013

Volume 104 Number 8

Science and Law: The Gleevec Case

10 October 2011
EDITORIAL

Laws passed by the Legislature in a democracy are always subject to judicial interpretation. In India, with very few exceptions, laws are framed by the executive, debated, refined, amended and enacted by Parliament and interpreted and enforced by the judiciary. Litigation and popular pastime in democracies and lawyers abound.

Lawyers, by definition, can provide the most compelling arguments. Courtroom dramas can provide opposing points of view. In real life and on the screen, Spencer Tracy's verdict, the battle waged by Novartis to obtain a patent for its anti-cancer drug Gleevec (Glivec) in India, prompted me to draw attention to the law and science in this column. The judgement delivered on 1 April 2013, by a two-judge bench, dismissed Novartis' claims, opening the door to manipulation of generics, which, dramatically lower costs of patient care.

The reactions to the Gleevec case, which, dramatically

vast majority of observers concerned about the unafford-

Science, Medicine and Law



“Steam is not a chemical”

Bombay High Court
Times of India, April, 2010

Chemical: 4% Sales Tax

Non Chemical: 10% Sales Tax

It is fact that in taxing statute the words which are not of technical expression or words of art, but are words of everyday use, must be understood and given a meaning, not in their scientific sense, but in a sense as understood in common parlance.

**Tax assessment years 1988-1991
Judgment: 2010**

Royal Society of Chemistry in UK offers a prize of GBP 1 million to any one who provides a sample of a material that is chemical free.

Is ‘aloo bonda’ processed vegetable? SC says no

THE TIMES OF INDIA India

Sep 1, 2015



(Representative image: TOI)



VAT 13%

VAT 4%

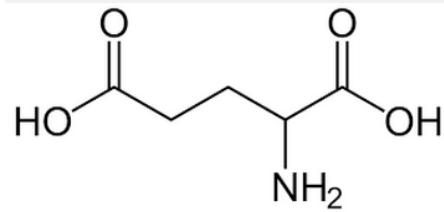
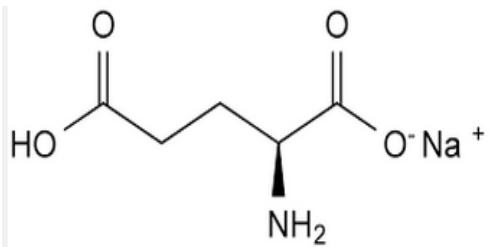
Bengaluru-based Merino Industries Ltd –



Gujarat bans Yippee noodles, Bambino macaroni after Maggi noodles

Times of India - 2 days ago

The government had extended the ban on Nestle's **Maggi** noodles for one month last ...



Monosodium L-glutamate: a double-blind study and review.

Tarasoff L¹, Kelly MF. *Food Chem Toxicol*. 1993 Dec;31(12):1019-35.

The present study led to the conclusion that 'Chinese Restaurant Syndrome' is an anecdote applied to a variety of postprandial illnesses; rigorous and realistic scientific evidence linking the syndrome to MSG could not be found.

India rejects patent on Pfizer's arthritis drug

Reuters Sept 7, 2015



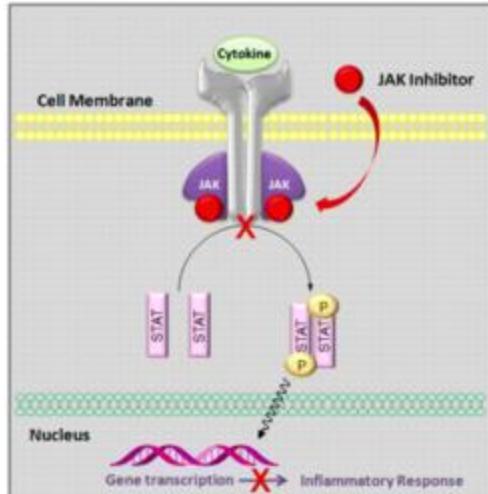
Rheumatoid arthritis (RA)

Psoriasis

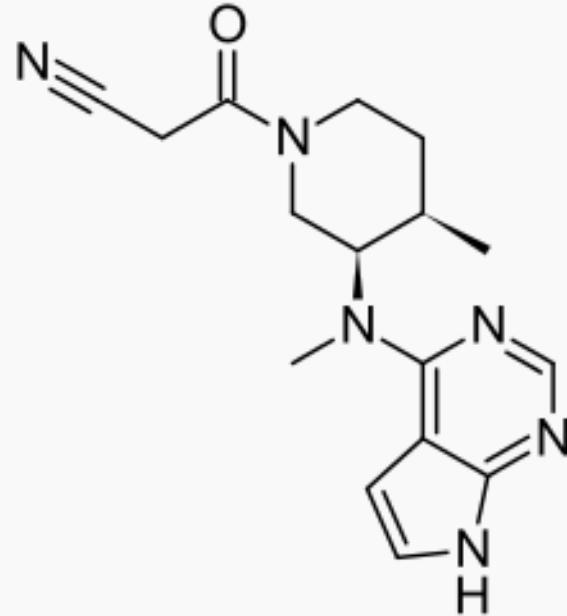
Inflammatory bowel disease

Immunological diseases

Organ transplant rejection.



Tofacitinib



Systematic (IUPAC) name

3-[(3*R*,4*R*)-4-methyl-3-[methyl(7*H*-pyrrolo[2,3-d]pyrimidin-4-yl)amino]piperidin-1-yl]-3-oxopropanenitrile

janus kinase (JAK) inhibitor

> \$ 2000 per month

GLEEVEC (Imatinib, STI571)



Novartis
Rs 1, 20,000 / Month

NATCO Pharma
Rs 8,000 / Month



Imatinib (Gleevec) as a Paradigm of Targeted Cancer Therapies

Brian J. Druker, MD

OHSU CANCER INSTITUTE

Glivec® : A New Causative Treatment Modality for CML



- **Glivec® (Gleevec®, imatinib, ST1571) was the first LMW kinase inhibitor to enter the market**
- Targets the genetic abnormality underlying **CML (Chronic Myeloid Leukaemia)**
- **Fastest ever US FDA approval for a cancer drug (2.5 months)**

Supreme Court of India

Novartis Ag

vs

**Union Of India & Ors. on
NATCO PHARMA LTD.**

M/S CANCER PATIENTS

AID ASSOCIATION

In view of the findings that the patent product, the beta crystalline form of Imatinib Mesylate, fails in both the tests of invention and patentability as provided under clauses (j), (ja) of section 2(1) and section 3(d) respectively, the appeals filed by Novartis AG fail and are dismissed with cost. The other two appeals are allowed.

Justice Aftab Alam

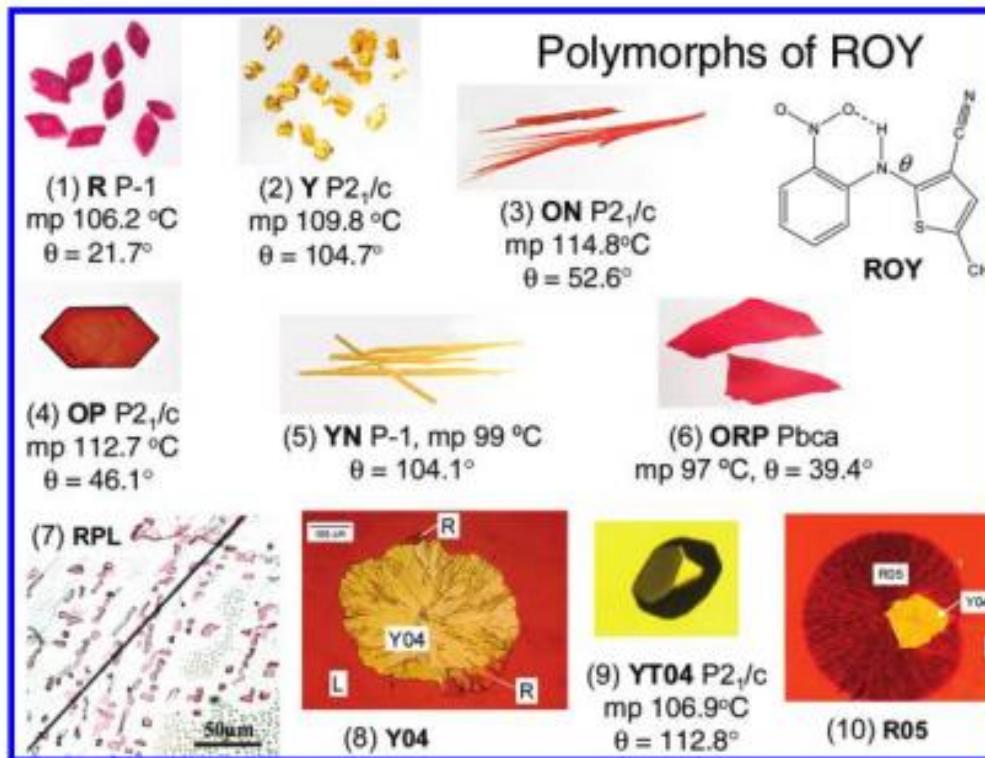
Justice Ranjana Prakash Desai

1 April, 2013

Polymorphs

Polymorphism is the ability of a solid material to exist in more than one form or crystal structure.

5-Methyl-2-[(2-nitrophenyl)amino]-3-thiophenecarbonitrile (ROY)



The polymorphs have different colors, melting points, and molecular conformations.

“The Supreme court is final not because it is infallible but it is infallible because it is final.”

V. R. Krishna Iyer
The Hindu, April 13, 2013

Disease : Chronic Myelogenous Leukaemia (CML)

Haematological Stem Cell Disorder Proliferation of Myeloid Cells

Chronic phase

Median 4–6 years stabilization

Advanced phases

Accelerated phase

Median duration up to 1 year

Blastic phase (blast crisis)

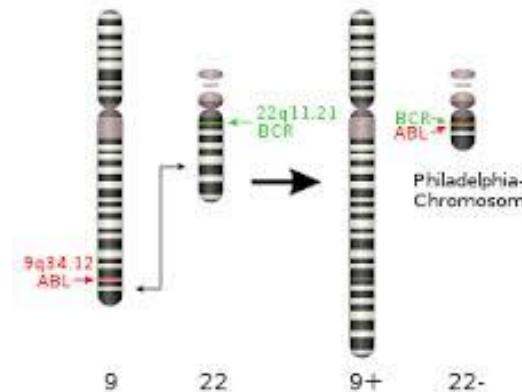
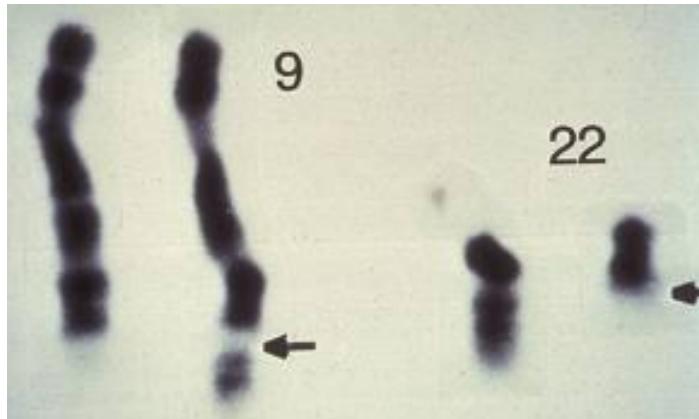
Median survival 3–6 months

Nature Reviews | Drug Discovery

Renaud Capdeville, Elisabeth Buchdunger, Juerg Zimmermann & Alex Matter
Nature Reviews Drug Discovery 2002, 1, 493-502

Cause:

**Genetic, Philadelphia Chromosome
Shortened Chromosome 22 (1960)**



Molecular Consequence
Creation of BCR-ABL gene

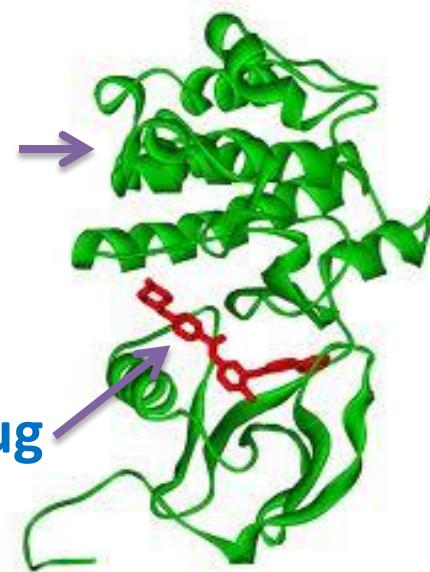


Gene Product

**Protein with Elevated Tyrosine Kinase Activity
(BCR-ABL Kinase)**

Protein Target

Drug



Gleevec- Development Studies

May
2001

Gleevec development timeline

1990

1990 – Lead compound identified in a screen for inhibitors of PKC.

1996

1996 – *In vivo* activity shown in BCR-ABL-transformed cells in syngeneic mice.

June

1998

June 1998 – First patient with CML treated.

June

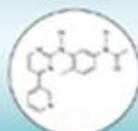
2000

June 2000 – Phase III trials initiated.

May 2001 – Approved by the FDA for CML.

November 2001 – Approved in Europe and Japan for CML.

Discovery



1992 – First batch of Gleevec synthesized.

1992

Clinical development



June 1999 – Phase II trials initiated.

February 2001 – NDA submitted to FDA for CML.

February 2002 – Approved by the FDA for GIST.

June 1999

Feb. 2001

Feb. 2002

Typical development timeline

Discovery

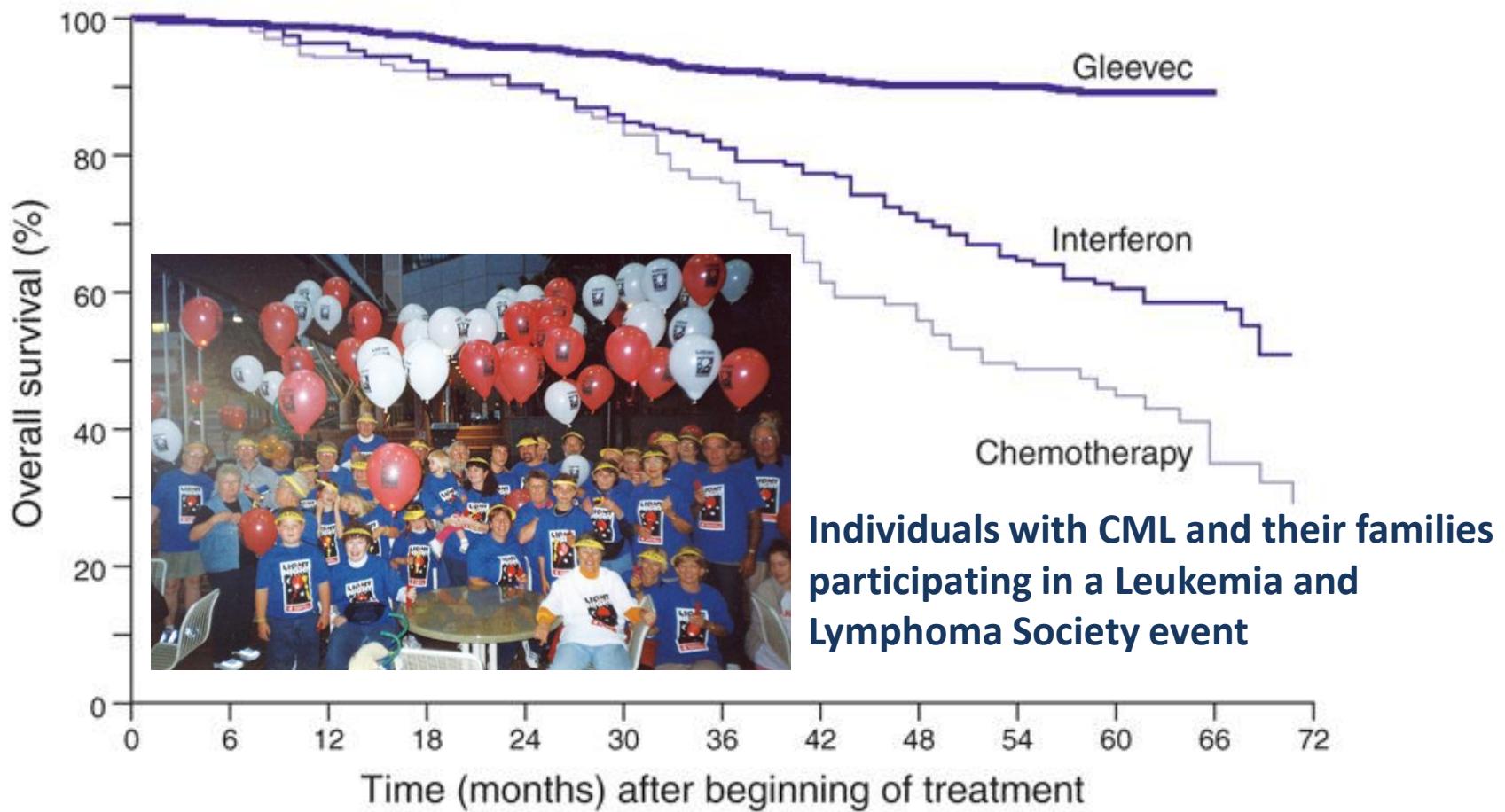
Typically ~8 years

Clinical development

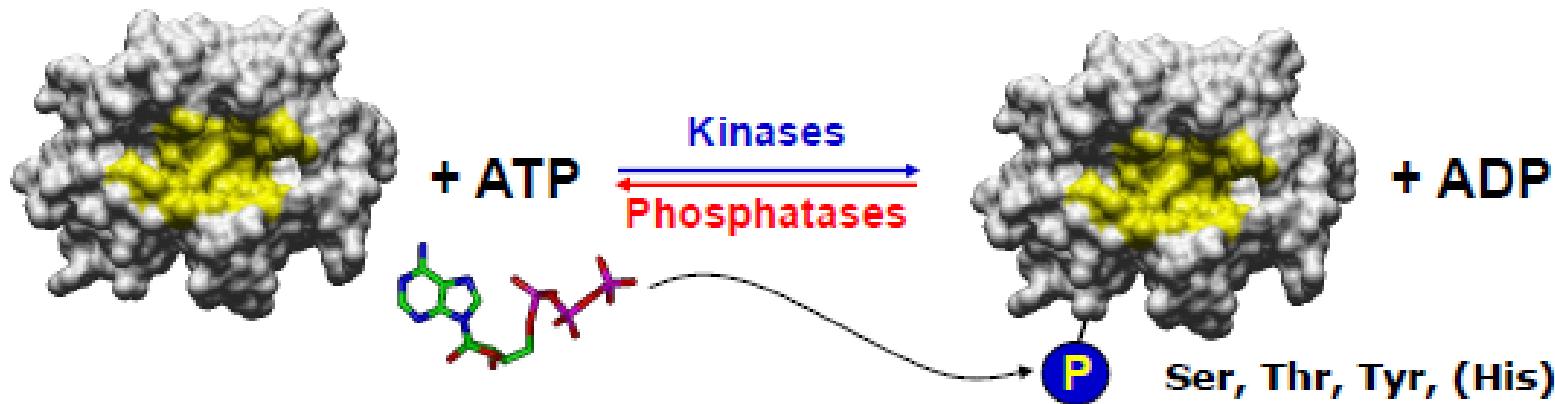
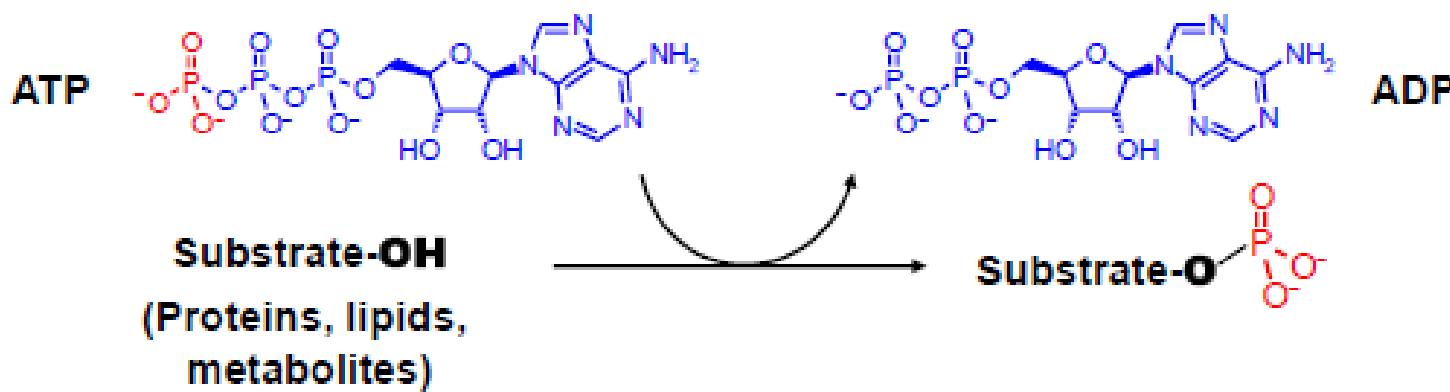
Typically ~7 years

Renaud Capdeville, Elisabeth Buchdunger, Juerg Zimmermann & Alex Matter
Nature Reviews Drug Discovery 2002, 1, 493-502

Survival of Patients with CML.



Kinases or The Art of Phosphate Transfer



The Discovery of Glivec: Phenyl Aminopyrimidines as Leads for PKC Inhibition



- Weak inhibitors of PKC
- Potential for diversification
- Simple synthesis
- Drug-like properties

The Ultimate Challenge of Drug Discovery or Making a Potent Inhibitor is Not Good Enough

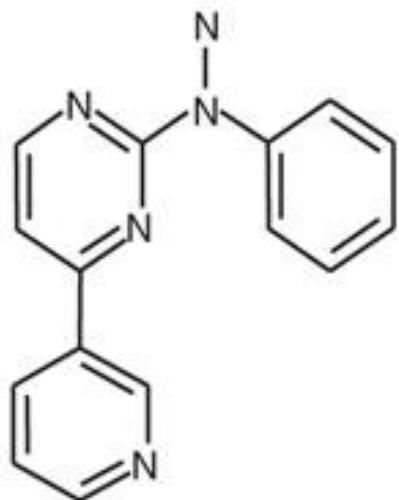
- A viable drug candidate needs to have “drug-like” properties:
 - Potent activity against target protein
 - Reasonable physico-chemical properties (e. g. solubility, polar surface area, single polymorph)
 - Reasonable metabolic stability
 - Sufficient oral bioavailability and acceptable PK profile
 - Predictable PK/PD relationship
 - Lack of toxicity, acceptable therapeutic window
 - Technical feasibility (complexity of synthesis, formulatability, cost of goods)

etc.

Lead optimization

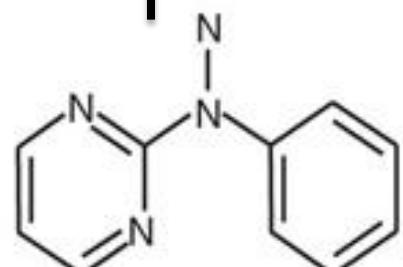
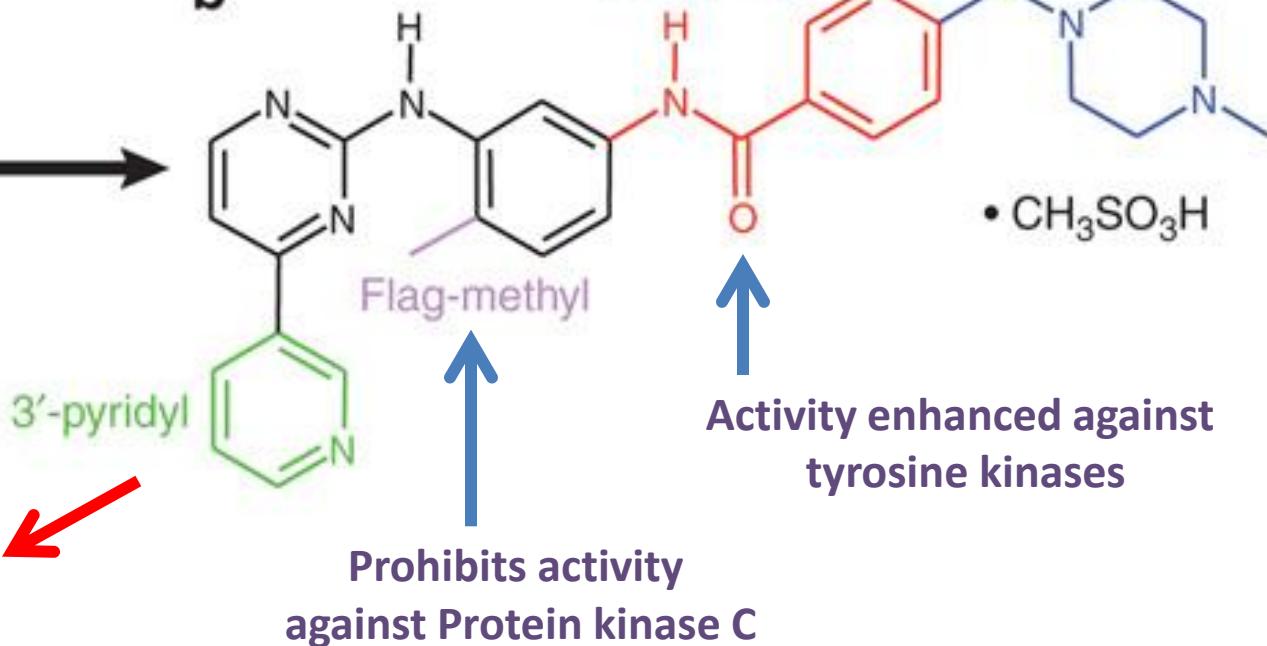
Increases water solubility & oral bioavailability

a



→

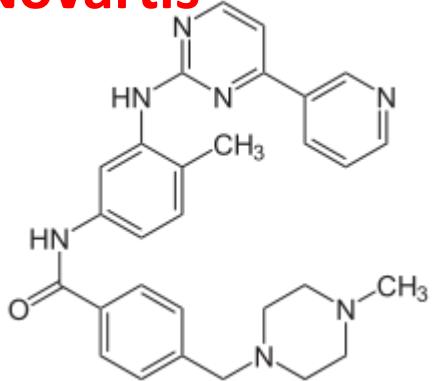
b



2-phenylaminopyridine

Nicholas Lydon
Nature Medicine 15, 1153 - 1157 (2009)

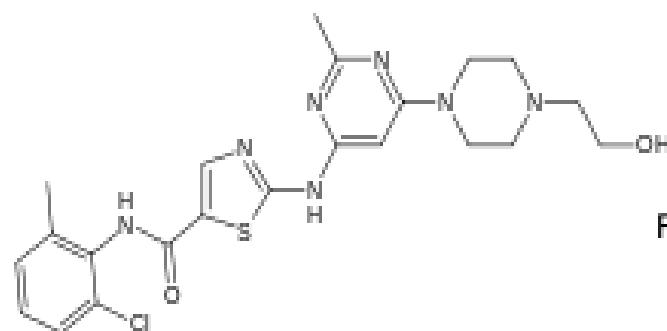
Novartis



a

Imatinib

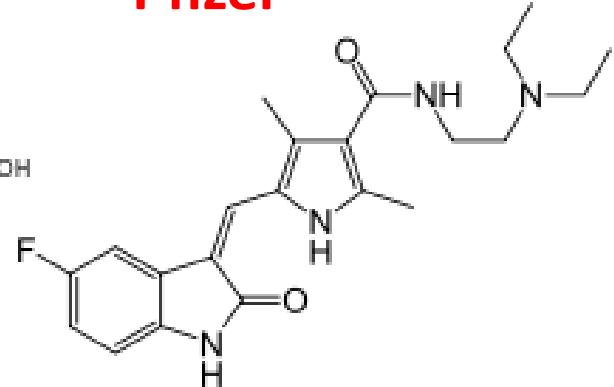
Bristol-Myers Squibb



b

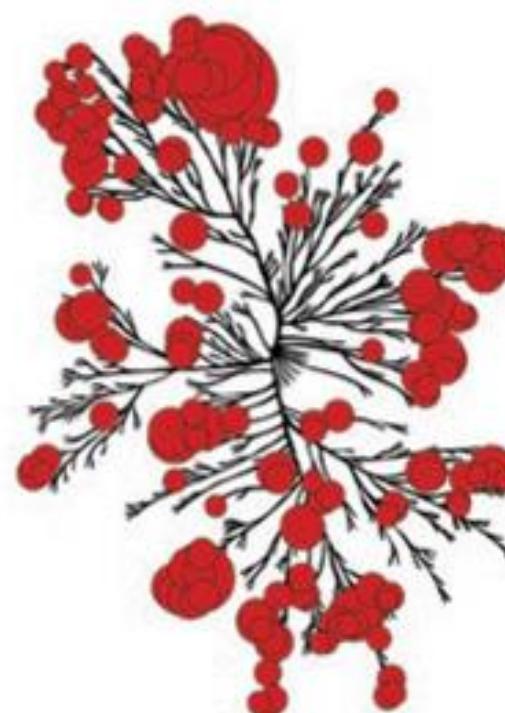
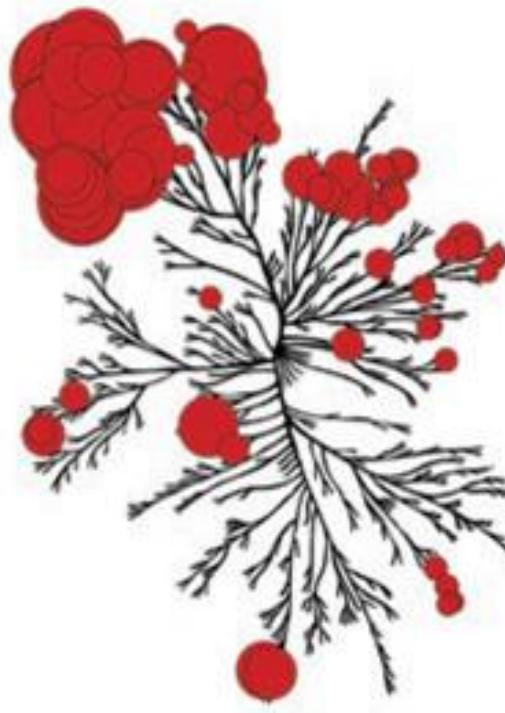
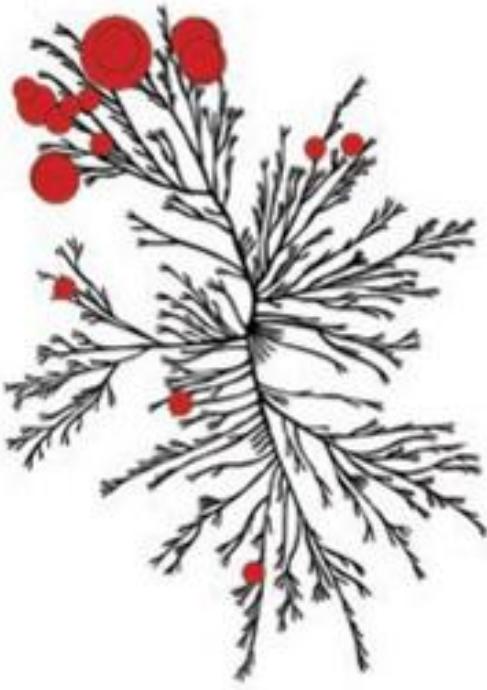
Dasatinib

Pfizer



c

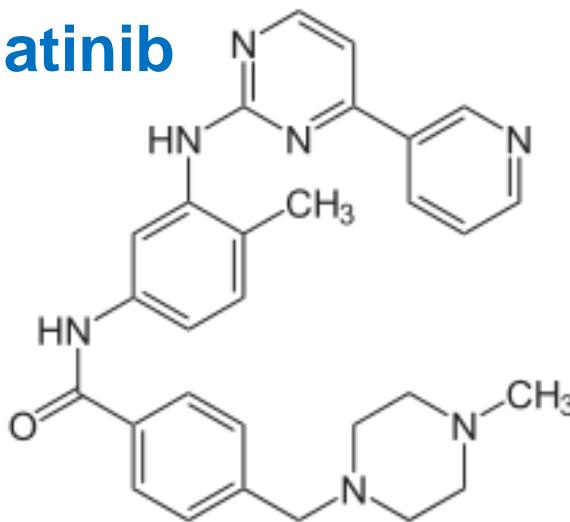
Sunitinib



Kinase Dendrogram

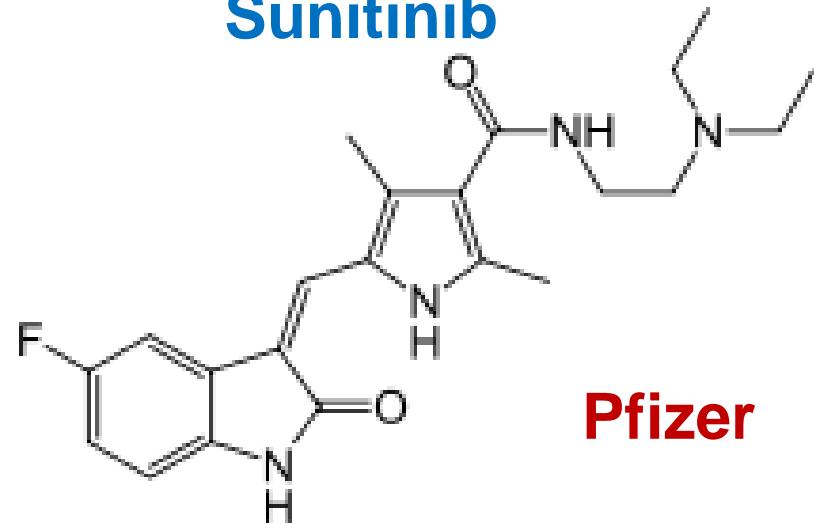
Nicholas Lydon, *Nature Medicine* 15, 1153 - 1157 (2009)

Imatinib



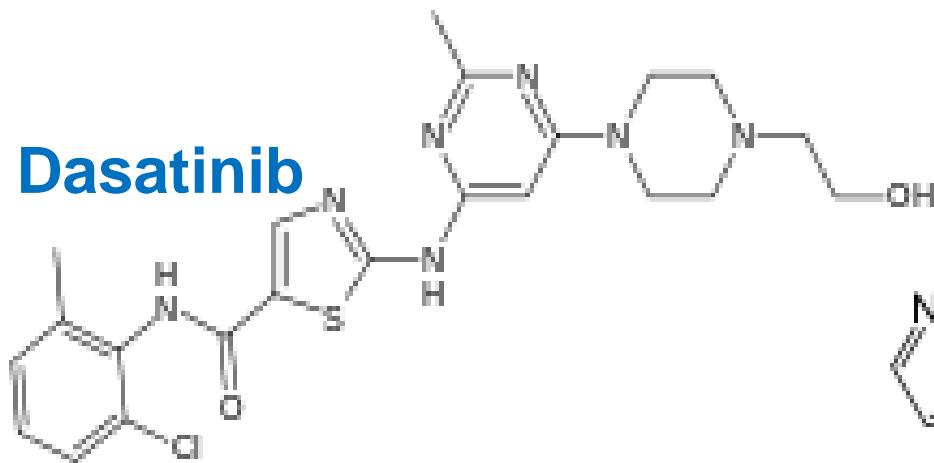
Novartis

Sunitinib

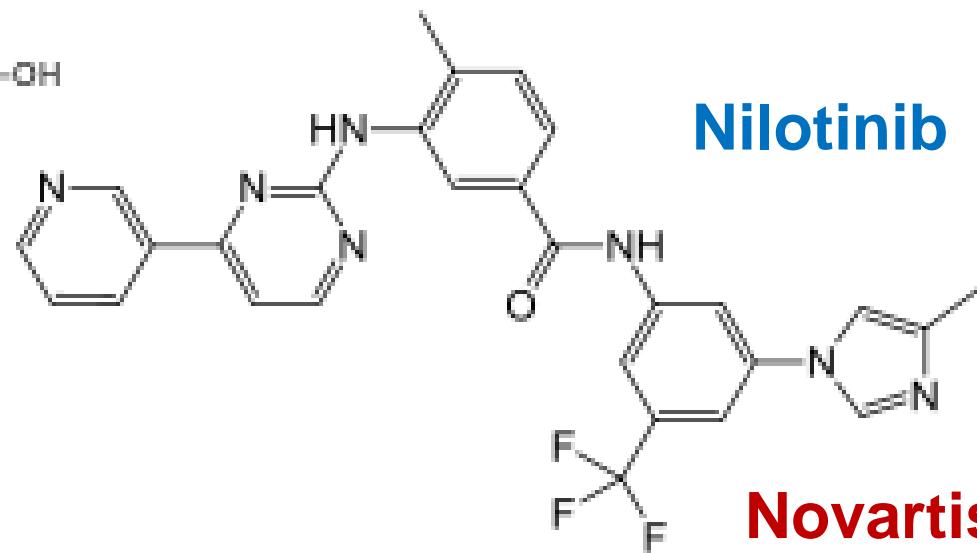


Pfizer

Dasatinib

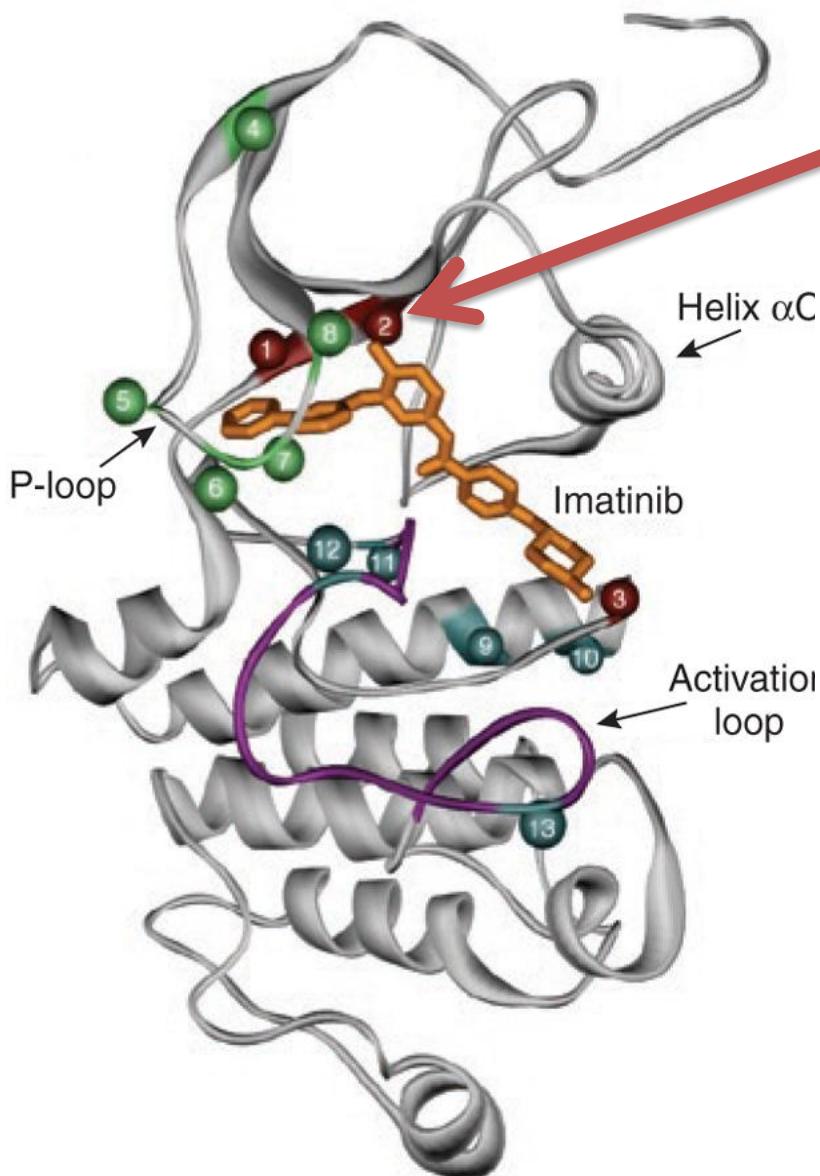


Bristol-Myers Squibb

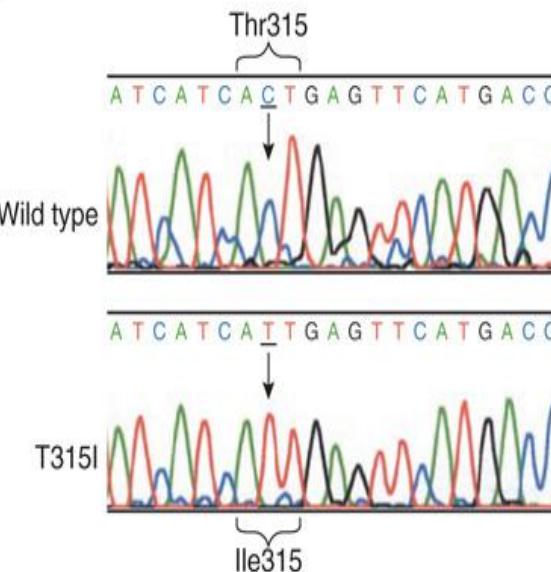


Novartis

ABL Kinase Domain Structure Bound to Imatinib Locations of 13 Resistance Mutations Indicated.



Sequence trace revealing the T315I mutation



Wall Street Journal, June 20, 2001

'Wonder Drug'
For Leukemia
Suffers Setback

By DAVID P. HAMILTON
And VANESSA FUHRMANS
Staff Reporters of THE WALL STREET JOURNAL

Gleevec, the cancer therapy hailed as a wonder drug against certain types of tumors, turns out to have an Achilles' heel after all: More than half of late-stage patients with chronic myeloid leukemia who initially benefited from the drug have seen their cancer return within six months, an often-fatal relapse.

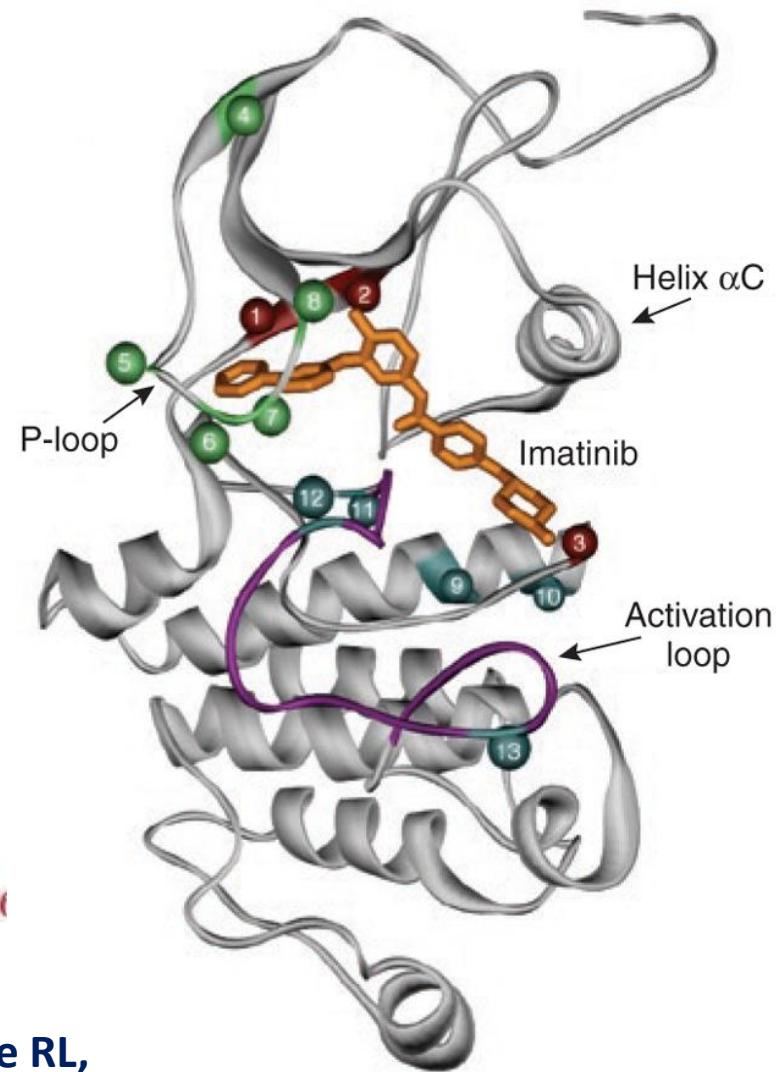
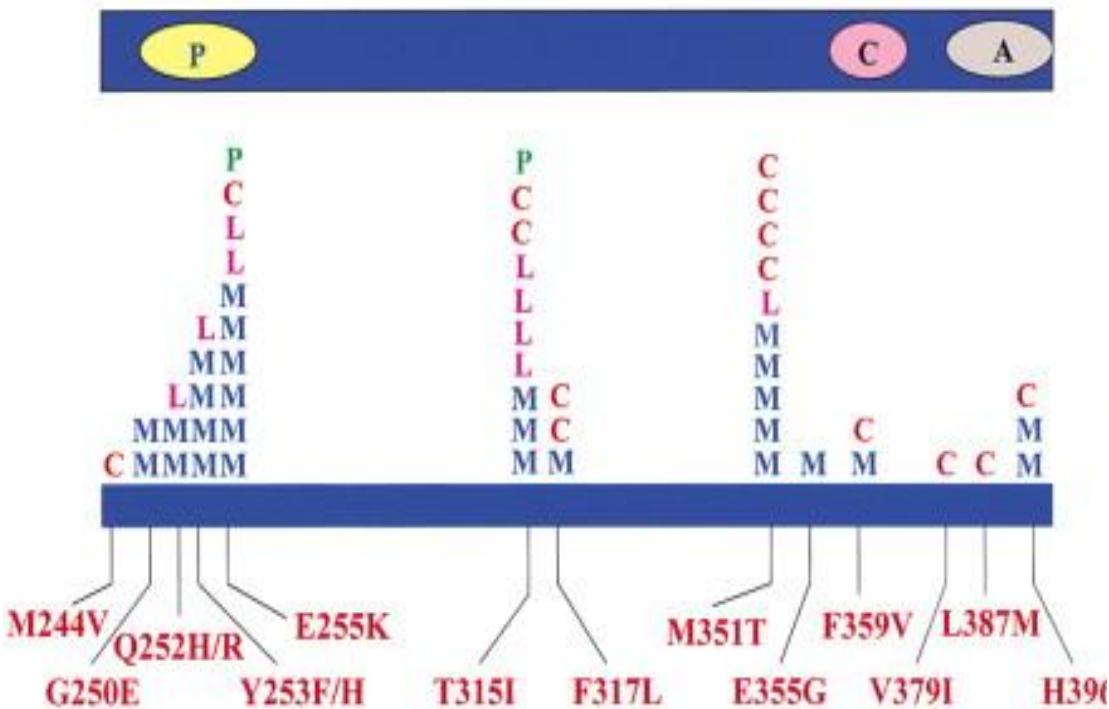
Charles L Sawyers

Nature Medicine 15, 1158 - 1161 (2009)

Shah NP, Nicoll JM, Nagar B, Gorre ME, Paquette RL, Kuriyan J, Sawyers CL. Cancer Cell 2, 117–125

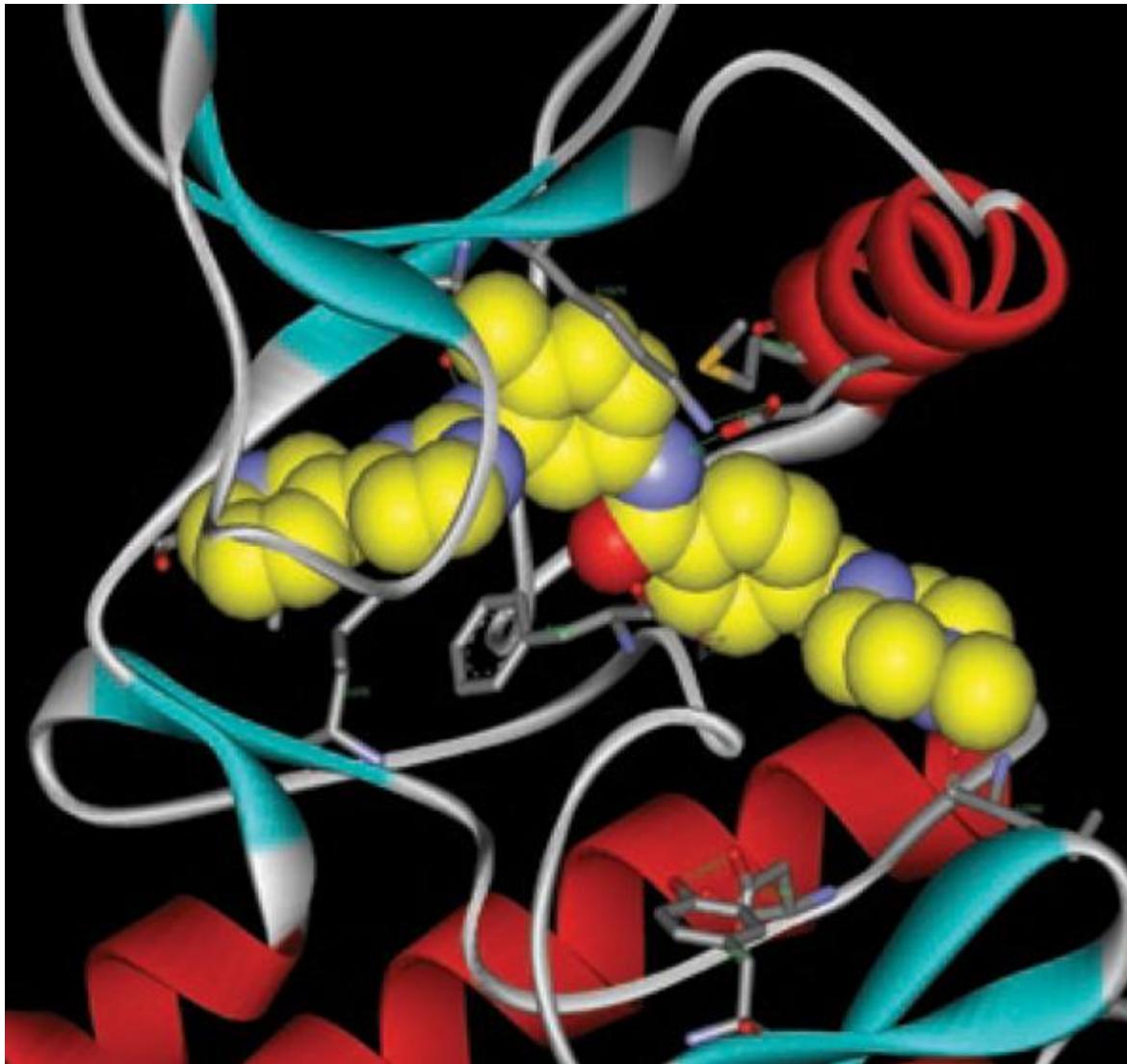
Summary of Imatinib-Resistant *BCR-ABL* Kinase Domain Mutations

BCR-ABL kinase domain



Shah NP, Nicoll JM, Nagar B, Gorre ME, Paquette RL,
Kuriyan J, Sawyers CL. *Cancer Cell* 2, 117–125

Imatinib Bound to the Inactive, Closed Conformation of ABL



Nicholas Lydon, *Nature Medicine* 15, 1153 - 1157 (2009)

How Much Does the Drug Development Process Cost?

<http://www.keionline.org/node/1697>

Gleevec Case:

Three Phase II Trials (1028 Patients) 2001 FDA Filing

Average Cost/ Patient (Phase I – III) - \$23,752/Patient

J.A. DiMasi et al.

Journal of Health Economics 22 (2003) 151-185

Risk Adjusted Cost of Trials

\$80 Million – (\$34 Million Lower bound)

\$96 Million – (\$38 Million) Cost of Capital + Overheads

Novartis Sales for Gleevec in 2012

\$4.675 Billion or \$390 Million/Month

R&D Cost for Gleevec (James Love, April 3, 2013)

Knowledge Ecology International

Early research on Gleevec: Share of funding

- 50% National Cancer Institute
- 30% Leukemia and Lymphoma Society
- 10% Novartis
- 10% Oregon Health and Science University

Include Phase I Trials

Novartis was not "the innovative force." Not only was all the basic research done in academic institutions, but so were the initial clinical investigations that showed STI 571 to be specifically effective against CML cells in vitro and in vivo. In fact, it took a few years for Brian Druker, the investigator most responsible for these latter studies, to convince Novartis that it should invest in a crash program to develop Gleevec and to undertake large-scale clinical trials.

Relman, A. (2003).

Book Review: Magic Cancer Bullet: How a Tiny Orange Pill Is Rewriting.
Medical History. JAMA, 290: 2194-2195



THE HINDU, June 29, 2013

Parliament Debate

Opposition member: “Sir, even if this were a Bill, which affects only India, still it would be an extremely important one. But it is a Bill, which affects most parts of the world. We are supplying 50 per cent of the cheapest drugs in the world to places like Papua New Guinea, Laos, Kenya, Africa, etc. All these countries have complained to the WHO about this Bill.

.....

It is a Bill that affects so many parts of the world. Do you not think that we should have a slightly more serious discussion on it, rather than attempting to pass it through?

- 1. We need to limit the scope of patentability to only new chemical entities.**
- 2. No patents for new usage and dosage of known drugs.**
- 3. Retain pre-grant opposition in its original form.**
- 4. Simple procedures with a time limit for grant of compulsory licences.**
- 5. Immunity for generic drugs which are already available in the market.**
- 6. Introduction of ceiling on royalty to pharmaceutical companies**

Parliament Debate

Government Member allays fears by drawing attention to Clause 3 of the Bill which says:

The mere discovery of a new form of a known substance which does not result in the enhancement of the known efficacy of that substance or the mere discovery of any new property or new use for a known substance or of the mere use of a known process, machine or apparatus unless such known process results in a new product or employs at least one new reactant.

Supreme Court on the Parliament Debate

On December 18, 2004, the Bill to further amend the Patents Act, 1970, which was materially the same as Ordinance No. 7 of 2004, was introduced in Parliament. The Bill evoked a highly insightful and informed debate on the subject. To anyone going through the debate on the Bill, Parliament would appear keenly alive to national interests, human-rights considerations and the role of India as the producer and supplier of drugs to different parts of the world where impoverished humanity is critically in need of those drugs at cheap and affordable prices.

After the amendment with effect from Jan 1, 2005, section 3(d) stands as under:

“Section 3. What are not inventions. The following are not inventions within the meaning of this Act, -

(d) The mere discovery of a new form of a known substance which does not result in the enhancement of the known efficacy of that substance or the mere discovery of any new property or new use for a known substance or of the mere use of a known process, machine or apparatus unless such known process results in a new product or employs at least one new reactant.

Explanation. For the purposes of this clause, salts, esters, ethers, polymorphs, metabolites, pure form, particle size, isomers, mixtures of isomers, complexes, combinations and other derivatives of known substance shall be considered to be the same substance, unless they differ significantly in properties with regard to efficacy.”

“.....The claim for patent for beta crystalline form of Imatinib Mesylate would only appear as an attempt to obtain patent for Imatinib Mesylate, which would otherwise not be permissible in this country.”

Supreme Court

“Evergreening” – A business strategy

Are There Any Lessons To Be Learnt From the Gleevec Story?

- More Research
- More Inter-disciplinary Research
- More Medical Research

**Motivating Science Administrators, Researchers,
Teachers & Students to Understand the Problem**

Disease

**Failure of Biology
(Metabolic/Genetic/Environmental)**

Diabetes

Heart Disease

Cancer

Neurodegenerative

Infections

Bacterial

Viral

Fungal

Parasitic

Biological Assays for Evaluating Pharmaceutical Usefulness

1. Activity Testing on Infected Animal Models
Artemisinin–Malaria

2. Activity Testing on Cells
Antibiotics

3. Cell Based Biochemical Assays
Cardiovascular Agents

4. Activity Testing on Molecular Targets
Gleevec

Invention Vs Discovery

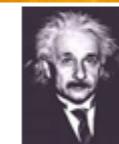
Mr Subramanium submitted that, by definition, a trifling change, or in the words of the section “a mere discovery of a new form of a known substance”, can never ordinarily meet the threshold of novelty and inventive step under clauses (j) and (ja) of section 2(1). An invention cannot be characterized by the word “mere”: The word “invention” is distinct from the word “discovery”.

Supreme Court

Discovery : Penicillin



**Invention : Light Bulb
Relativity**

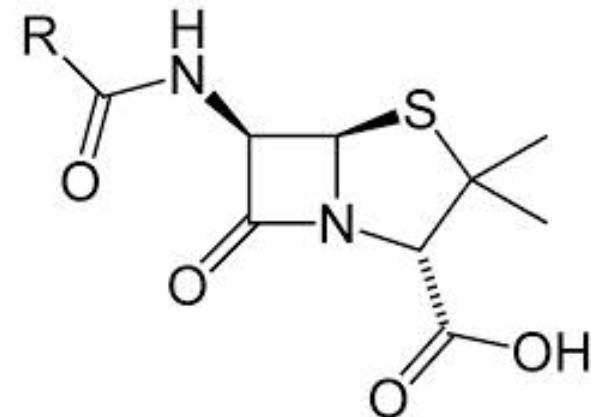
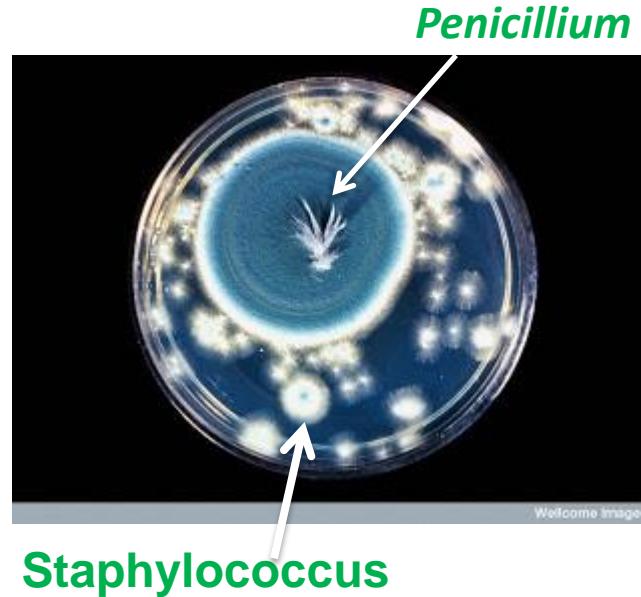
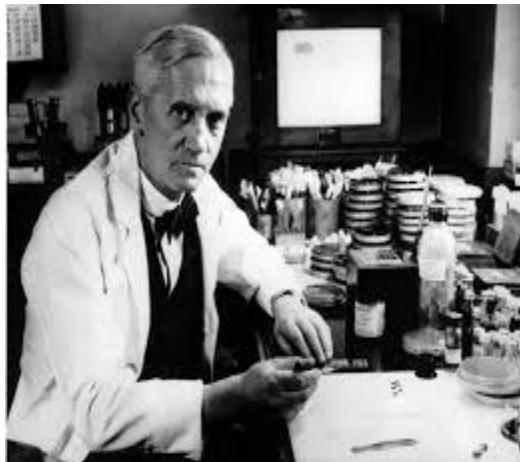


Innovation : Retail Store



Drug Discovery

1. Serendipitous (Accidental)



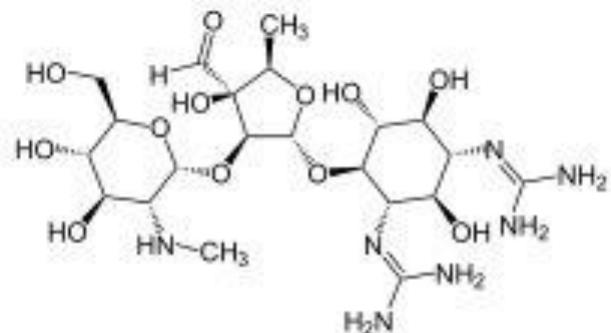
2. Design

**Biological Target Identification: Cellular/Molecular
Identifying the magic bullet**

(A) Rational Design

(B) Screening libraries of molecules

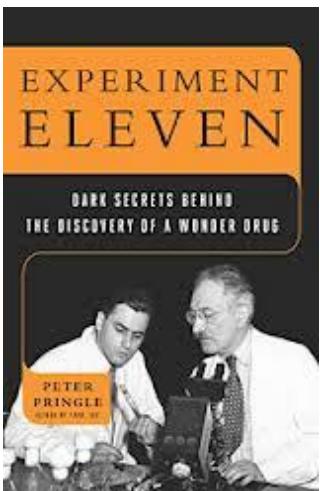
First Anti-Tuberculosis Drug



SELMAN A. WAKSMAN
Nobel Lecture, December 12, 1952

**The Lord hath created medicines out of the earth;
and he that is wise will not abhor them.**

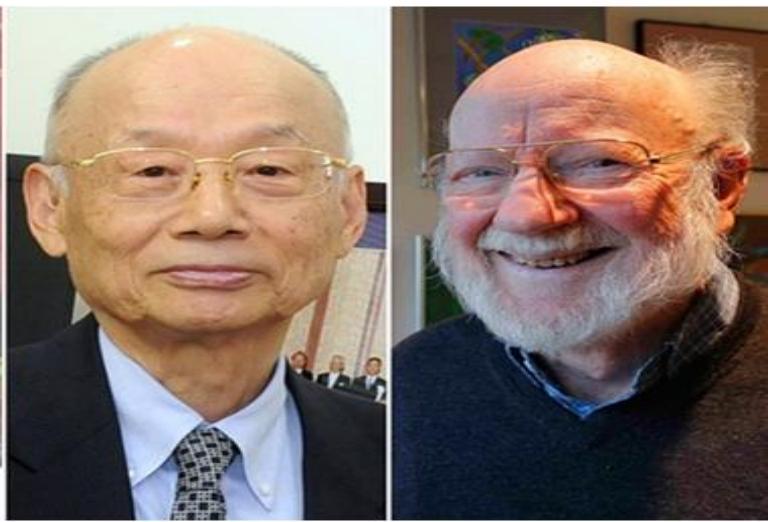
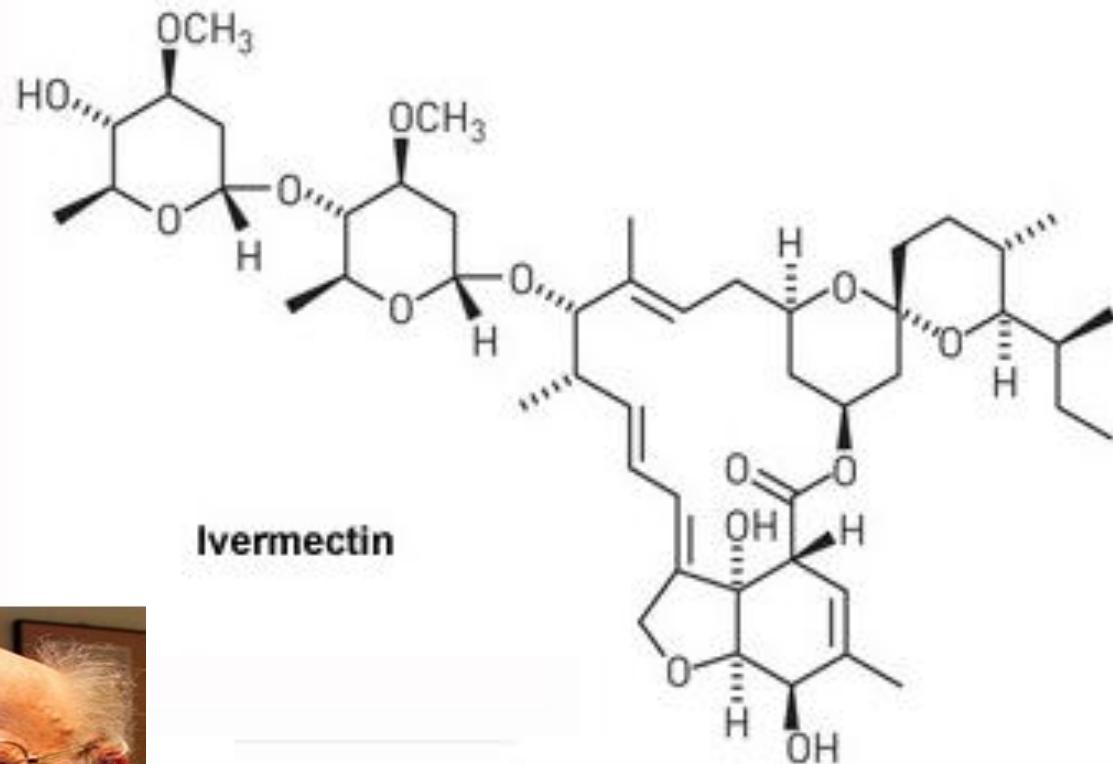
Ecclesiasticus, XXXVIII, 4



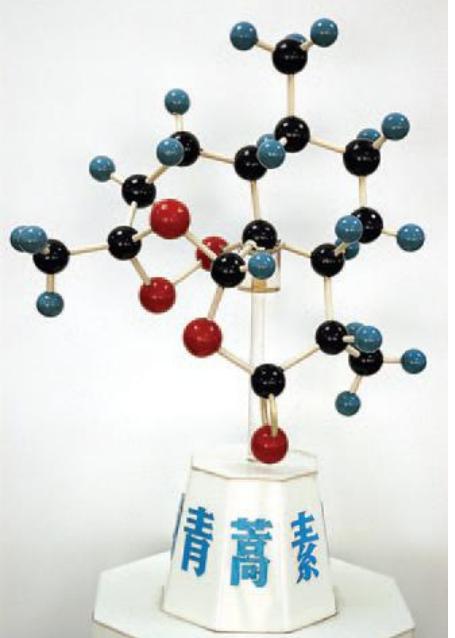
Inge Auerbacher
and Albert Schatz

FINDING DR. SCHATZ
*The Discovery of Streptomycin
and A Life it Saved*

William C. Campbell, Satoshi Ōmura and Youyou Tu Win 2015 Nobel Prize for Physiology or Medicine



Filariasis and African River Blindness

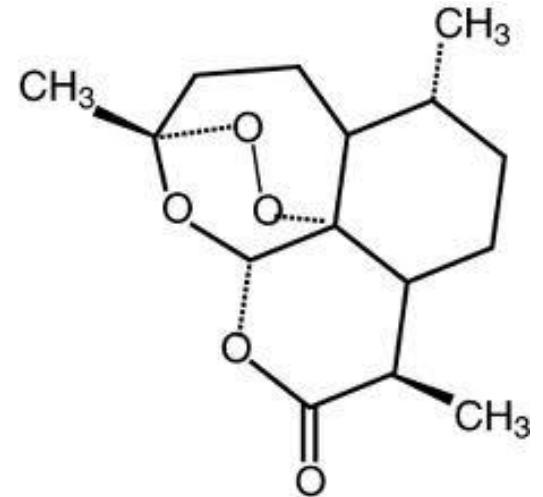


The discovery of artemisinin (qinghaosu) and gifts from Chinese medicine

Nature Medicine, 2011, 17, 1218



Youyou Tu



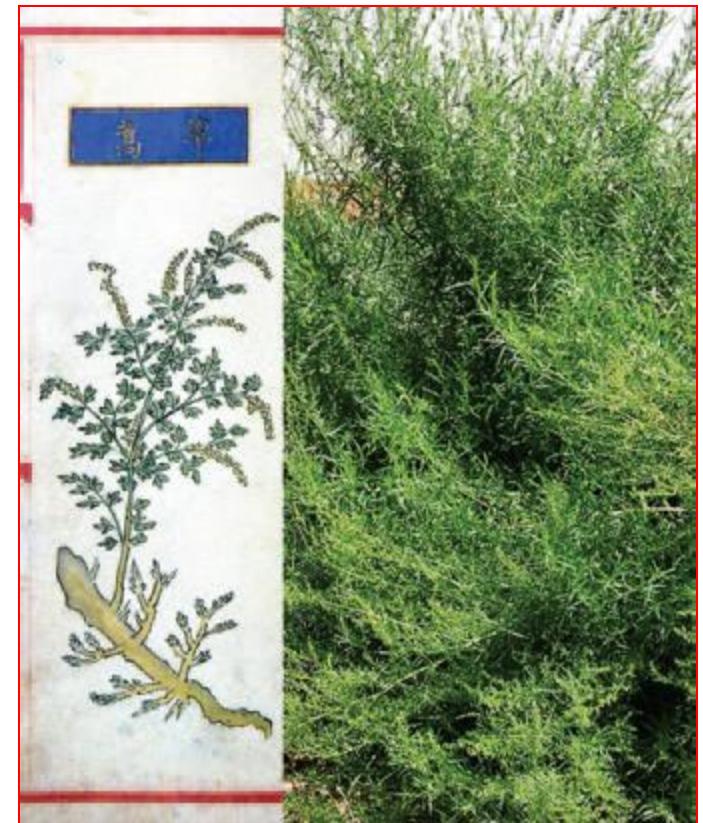
Artemisinin

Handbook of Prescriptions for Emergencies

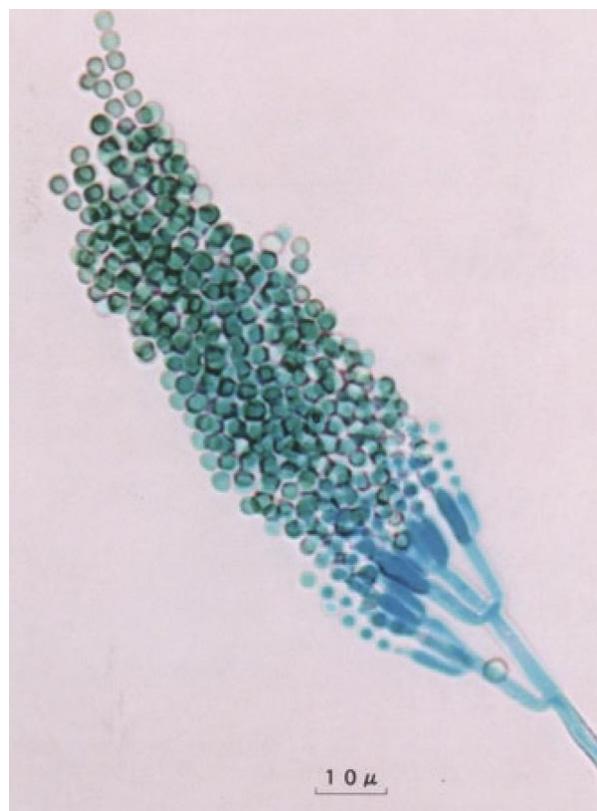


Ge Hong ~ 340 AD

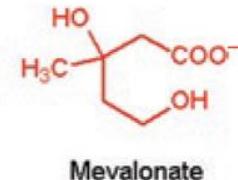
“A handful of qinghao emerges with 2 liters of water,
wring out the juice and drink it all”



**Micrograph of *Penicillium citrinum* Pen-51,
the fungus that produces compactin.**



Statins

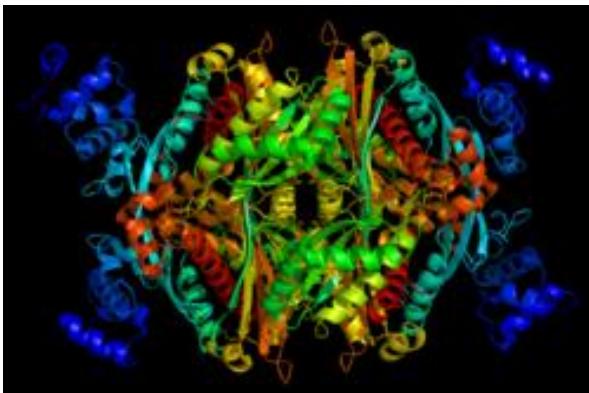


$R_1 = H$	$R_2 = H$	Compactin
$R_1 = H$	$R_2 = CH_3$	Lovastatin
$R_1 = CH_3$	$R_2 = CH_3$	Simvastatin
$R_1 = H$	$R_2 = OH$	Pravastatin

Cholesterol Lowering Agents

1971-1987

HMG-CoA Reductase



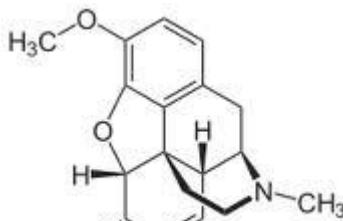
Akira Endo
Nature Medicine 14, 1050 - 1052 (2008)

Plant drugs of most economic value [modified from (2)]

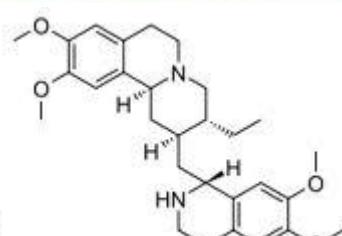
analgesic antitussive codeine morphine capsaicin	antiamoebic emetine	anticholinergic atropine hyoscyamine scopolamine	antihypertensive reserpine	antigout colchicine
antimalarial artemisinin quinine quinoline	antineoplastic camptothecin vinblastine vincristine taxol podophyllotoxin	aphrodisiac yohimbine	cardiac depressant quinidine	cardiotronic digoxin digitoxin
cholinesterase inhibitor galanthamine	cholinergic physostigmin pilocarpine	contraceptives hormonal drugs diosgenin hecogenin stigmasterol	emetic ipecac	laxative sennoside A & B
local anesthetic cocaine	muscle relaxant tubocurarine	smoking cessation nicotine		

Vincenzo De Luca, Vonny Salim, Sayaka Masada Atsumi, Fang Yu
Science 336, 1658 (2012)

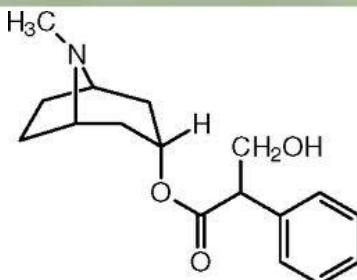
Plant drugs of most economic value [modified from (2)]



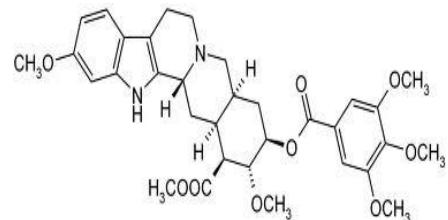
Codeine
(analgesic)



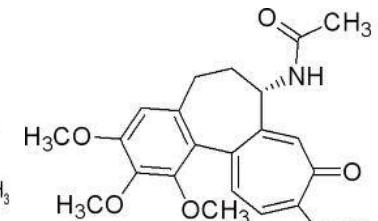
Emetine
(antiamoebic)



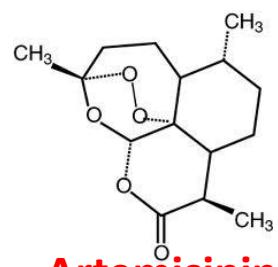
Atropine
(anticholinergic)



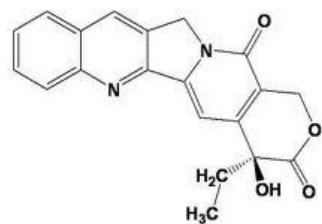
Reserpine
(antihypertensive)



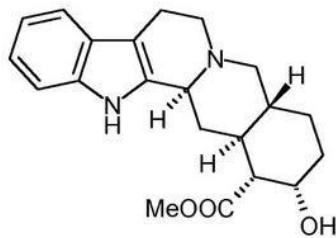
Colchicine
(antigout)



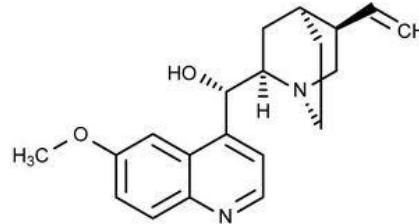
Artemisinin
(antimalarial)



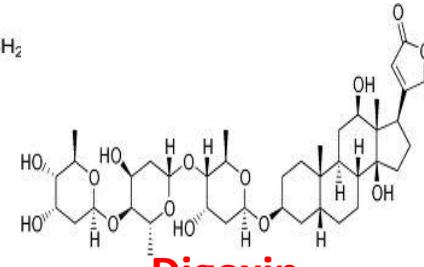
Camptothecin
(antineoplastic)



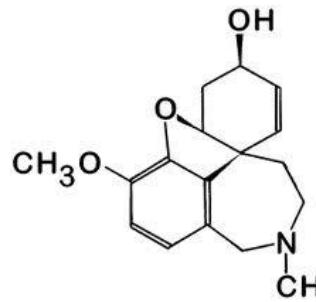
Yohimbine
(aphrodisiac)



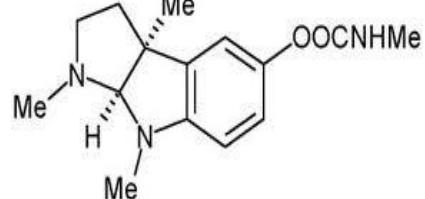
Quinidine
(cardiac depressant)



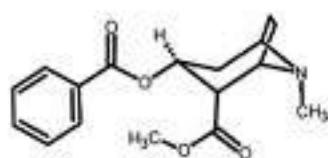
Digoxin
(cardiotonic)



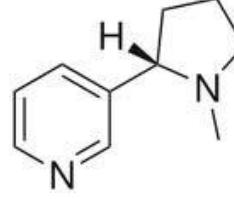
Galanthamine
(cholinesterase
inhibitor)



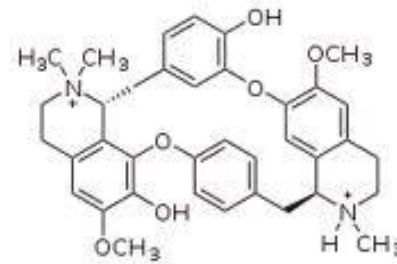
Physostigmine
(cholinergic)



Cocaine
(local anesthetic)



Nicotine
(smoking cessation)



Tubocurarine
(muscle relaxant)

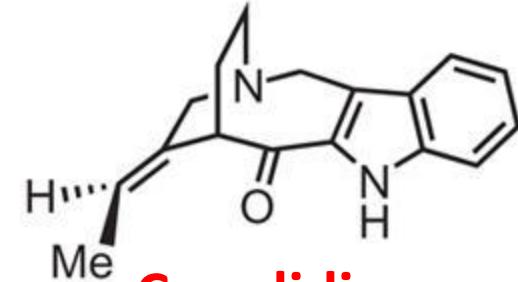
Synthesis of conolidine, a potent non-opioid analgesic for tonic and persistent pain

Michael A. Tarselli¹, Kirsten M. Raehal^{2,3}, Alex K. Brasher¹, John M. Streicher^{2,3}, Chad E. Groer^{2,3}, Michael D. Cameron², Laura M. Bohn^{2,3*} and Glenn C. Micalizio^{1*}

Nature Chemistry, 2011, 3, 449



Pinwheel flower
(*Tabernaemontana*
divaricata)

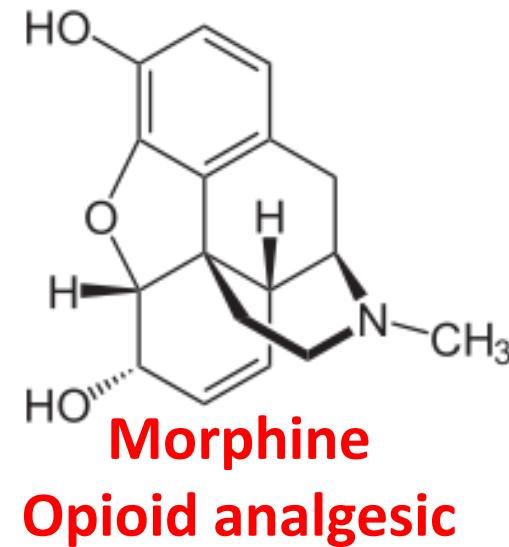


Conolidine
Non opioid analgesic



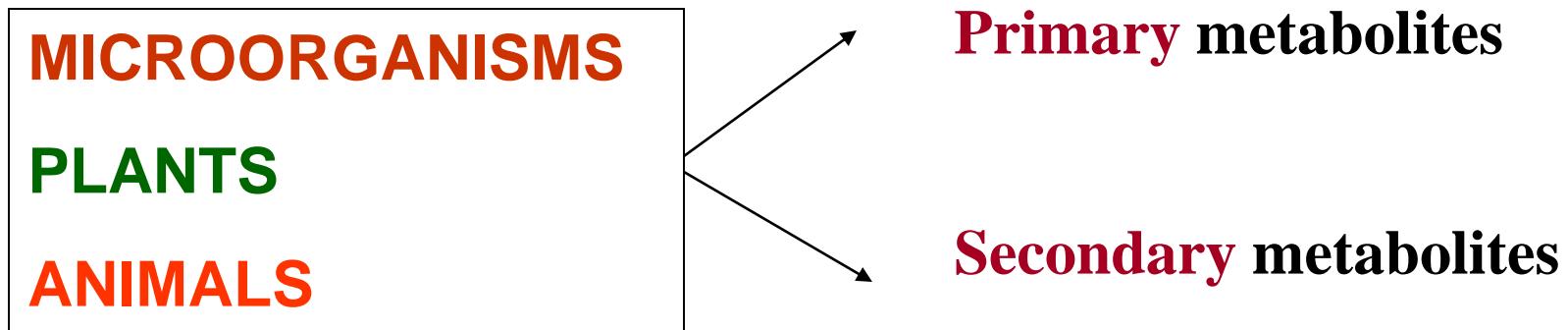
Opium Poppy

Addictive



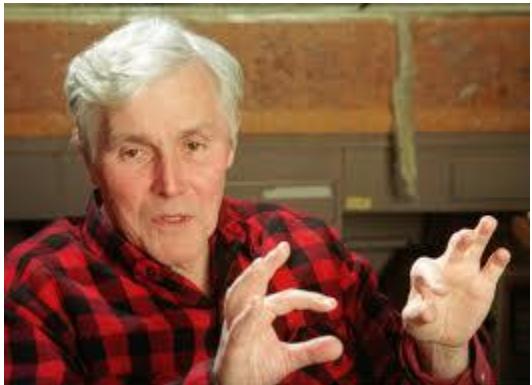
Morphine
Opioid analgesic

REVISITING THE CHEMISTRY OF NATURAL PRODUCTS



“Secondary metabolism represents the splendid, idiosyncratic diversity of nature, endowing different species with specific solutions to biological problems”

- J. W. BENNETT and R. BENTLEY
Adv. Appl. Microbiol. 1989, 34: 1.



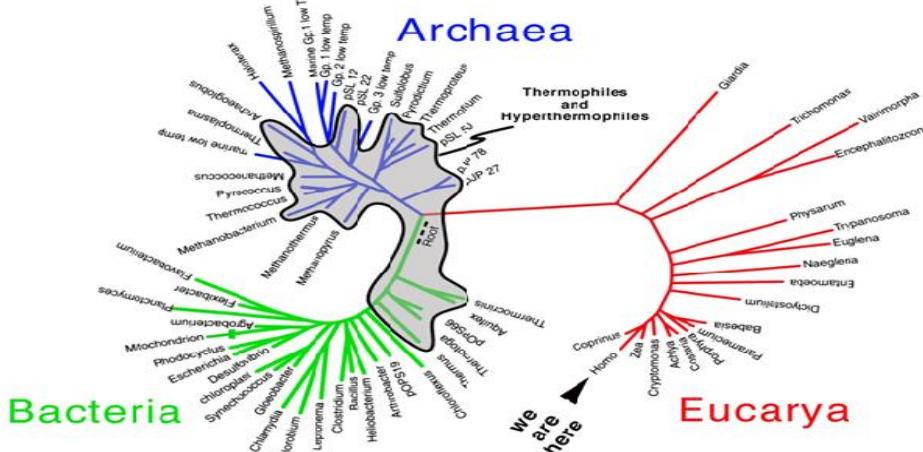
Carl Woese



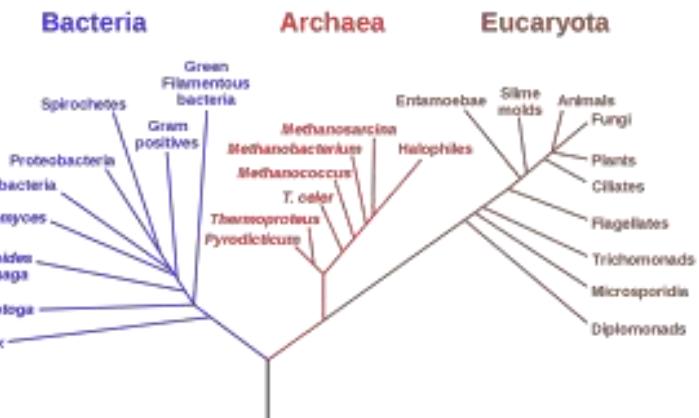
"Nature is to be found in Her entirety nowhere more than in Her smallest creatures." - Pliny the Elder

[Mark O. Martin](http://microbesrule.blogspot.in/2012_12_01_archive.html): http://microbesrule.blogspot.in/2012_12_01_archive.html

The Tree of Life



Phylogenetic Tree of Life

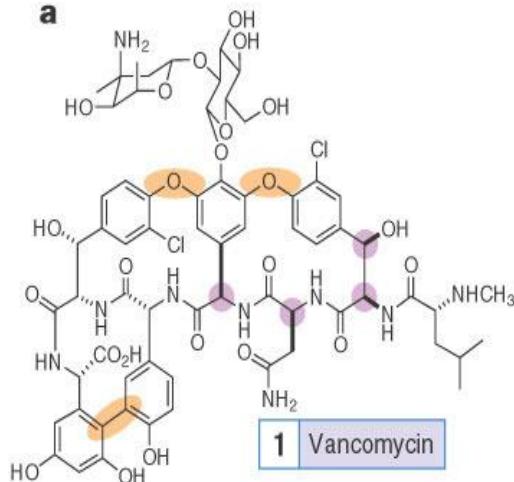


[http://students.washington.edu/
bowmanjs/wordpress/?p=666](http://students.washington.edu/bowmanjs/wordpress/?p=666)

Medically Significant Drugs

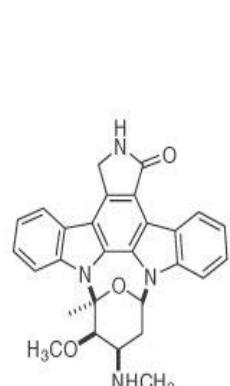
Natural Products

a



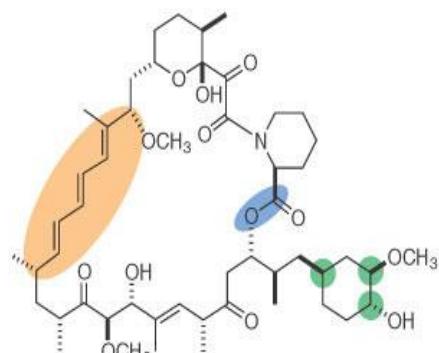
1 Vancomycin

Antibiotic



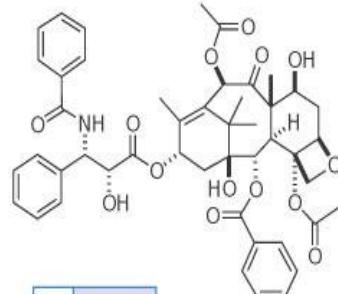
2 Staurosporine

Cancer



3 Rapamycin

Immunosuppression

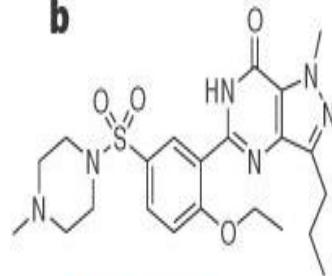


4 Taxol

Cancer

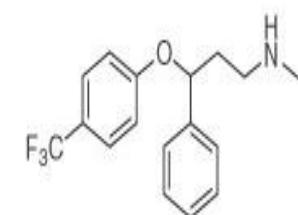
Synthetic Molecules

b



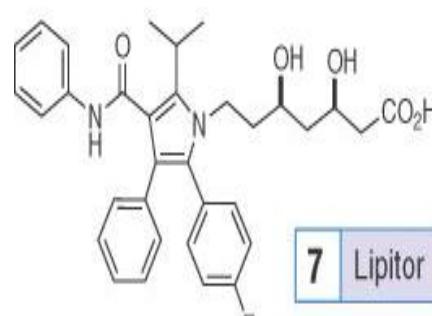
5 Viagra

Erectile Dysfunction



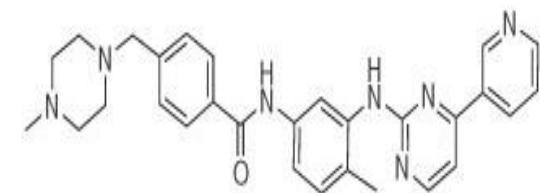
6 Prozac

Anti-depressant



7 Lipitor

Cholesterol Reduction

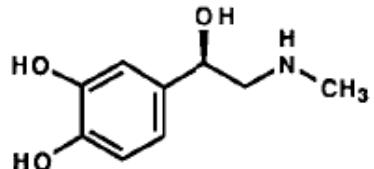


8 Gleevec

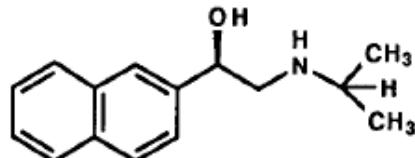
Cancer

Jon Clardy & Christopher Walsh
Nature 432, 829-837 (16 December 2004)

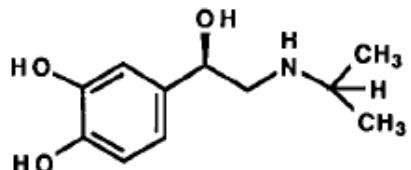
DRUGS FROM EMASCULATED HORMONES: THE PRINCIPLES OF SYNTOPIC ANTAGONISM



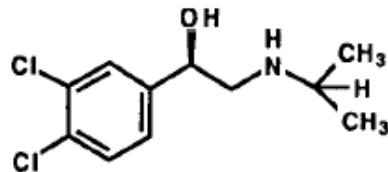
ADRENALINE



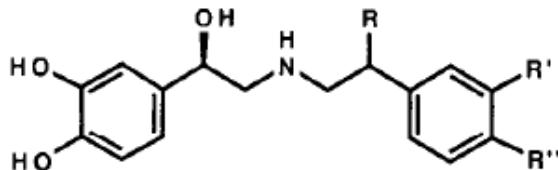
PRONETHALOL



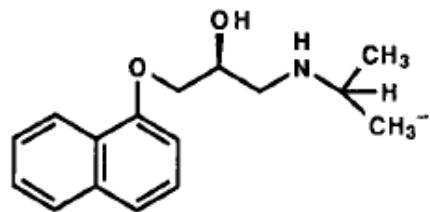
ISOPRENALE



DICHLOROISOPRENALE



DIBENZYLETHYLAMINES



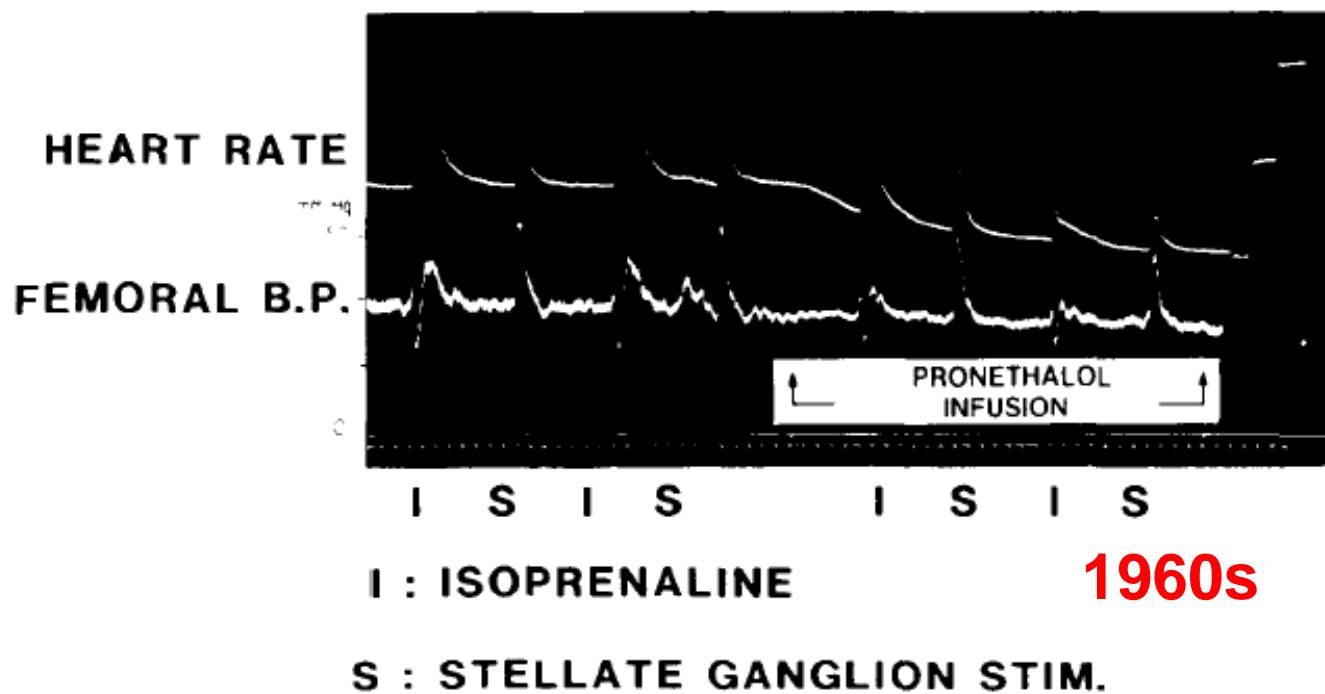
PROPRANOLOL

β - blocker



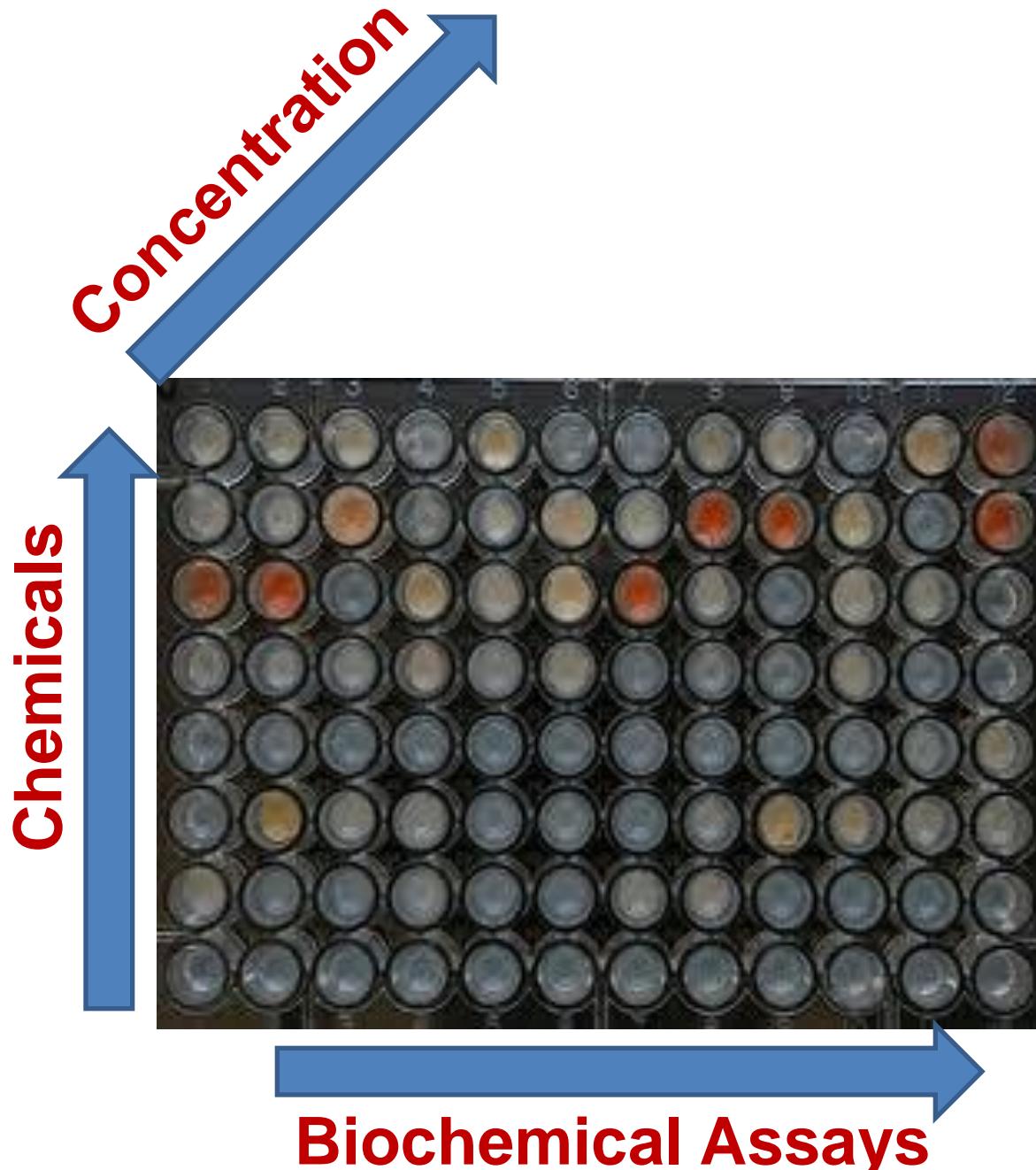
James Black
1924-2010

As analytical pharmacologists, what we are allowed to see of a new molecule's properties is totally dependent on the techniques of bioassay we use. The prismatic qualities of an assay distort our view in obscure ways and degrees. Our only defence lies in restless improvement in technique and experimental design, in the hope that collimation of several techniques will improve the reliability of our vision. We would make the change selfconsciously today, but then it was intuitive.



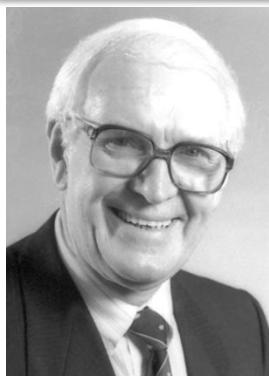
1960s

Searching For Drugs



My first prejudice is about the need to distinguish between invention and discovery. Discovery is about exposing the mysteries of nature, of what already exists. Invention is about creating something that never existed before. Discovery is the major activity in academic, University, research. Invention is the major preoccupation in industrial research. Discovery is about the excitement of travelling. Invention is about the satisfaction of arriving

The point that I want to make is that, psychologically, inventors and discoverers are different kinds of people with different needs and management. Perhaps we need the equivalent of football scouts to scour the academic research labs for frustrated individuals with ideas that they cannot get funded to do.



A Life in New Drug Research

James Black

British Journal of Pharmacology (2010) 160 (Suppl. 1) S15–S25



