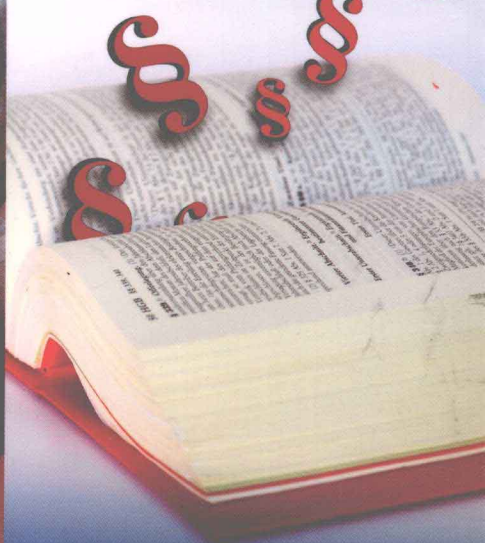
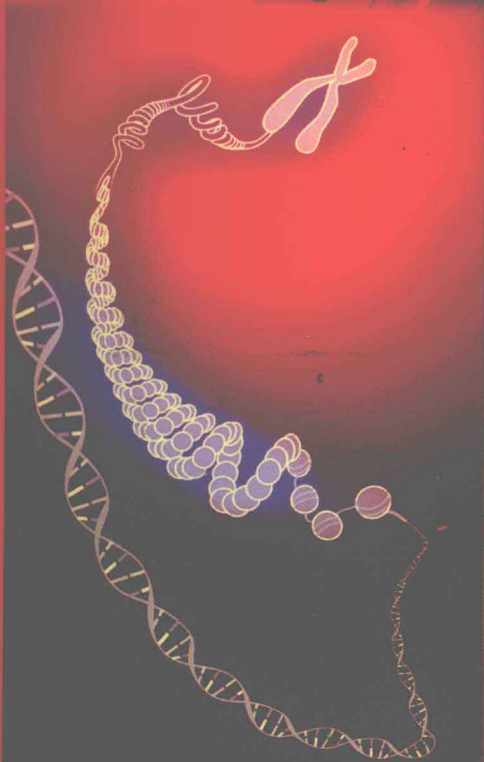


# An Introduction to Molecular Biotechnology

Fundamentals, Methods, and Applications  
Second, Updated Edition

Edited by Michael Wink



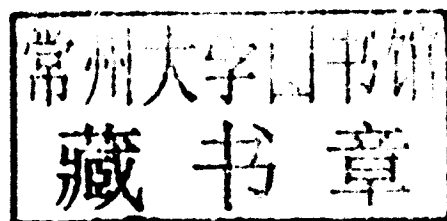
 **WILEY-  
BLACKWELL**

# **An Introduction to Molecular Biotechnology**

Fundamentals, Methods, and Applications

*Edited by*  
*Michael Wink*

Second, Updated Edition



#### **The Editor**

**Prof. Dr. Michael Wink**  
Institute of Pharmacy and  
Molecular Biotechnology  
University of Heidelberg  
Im Neuenheimer Feld 364  
69120 Heidelberg  
Germany

#### **Cover**

Pictures courtesy of Michael Knop, EMBL,  
Heidelberg (gel chromatography, pipet),  
National Human Genome Research Institute,  
Bethesda, USA (DNA), Fotolia/Franz Pfluegl  
(cereals), PhotoDisc/Getty Images (pills),  
Fotolia/SyB (stock exchange charts),  
Fotolia/Aintschie (law code)

**Limit of Liability/Disclaimer of Warranty:** While the publisher and authors have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty can be created or extended by sales representatives or written sales materials. The Advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

**Library of Congress Card No.:**  
applied for

**British Library Cataloguing-in-Publication Data**  
A catalogue record for this book is available from the British Library.

**Bibliographic information published by the Deutsche Nationalbibliothek**  
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <http://dnb.d-nb.de>.

© 2011 WILEY-VCH Verlag GmbH & Co. KGaA,  
Boschstraße 12, 69469 Weinheim

**Wiley-Blackwell** is an imprint of John Wiley & Sons, formed by the merger of Wiley's global Scientific, Technical, and Medical business with Blackwell Publishing.

All rights reserved (including those of translation into other languages). No part of this book may be reproduced in any form – by photoprinting, microfilm, or any other means – nor transmitted or translated into a machine language without written permission from the publishers. Registered names, trademarks, etc. used in this book, even when not specifically marked as such, are not to be considered unprotected by law.

**Composition** K+V Fotosatz GmbH, Beerfelden  
**Printing and Binding** betz-druck GmbH,  
Darmstadt

**Cover Design** Formgeber, Eppelheim

Printed in the Federal Republic of Germany

Printed on acid-free paper

**ISBN** 978-3-527-32637-2

## Preface

The term biotechnology was only coined in 1919 by the Hungarian engineer Karl Ereky. He used it as an umbrella term for methods by which microorganisms helped to produce valuable products. Humankind has been using biotechnological methods for thousands of years – think of the use of yeast or bacteria in the production of beer, wine, vinegar, or cheese.

Biotechnology is one of the key technologies of the twenty-first century. It includes established traditional industries such as the production of milk and dairy products, beer, wine, and other alcoholic drinks, as well as the production and bio-transformation of enzymes, amino acids, vitamins, antibiotics, and other fine chemicals. This area, including the associated process engineering, is referred to as **white or industrial biotechnology**. As it is well established, it will only be treated in passing in Chapter 34. Many good books have been written to cover the field.

Breathtaking progress has been made in molecular and cell biology in the past 50 years, particularly in the last 20–30 years. This opens up new exciting perspectives for industrial applications. This area of applied biology is clearly distinguished from the traditional biotechnological fields and is known as **molecular biotechnology**. In a few years' time, however, it may well be regarded as another established branch of traditional biotechnology.

Molecular biology and cell biology have revolutionized our knowledge about the function and structure of macromolecules in the cell and the role of the cell itself. Major progress has been made in genomics and proteomics. A historic milestone was the sequencing of the human genome in 2001. At present, more than 1200 genomes of diverse organismal groups (including more than 100 genomes of eukaryotes) have been completely sequenced (<http://www.ebi.ac.uk/genomes>). As a next milestone it has been proposed to sequence 10 000 genomes from species covering the tree of life (<http://www.genome10k.org>). With the new generation of DNA sequencers it is now possible to sequence the human genome in a matter of weeks. This new knowledge has had direct repercussions on medical science and therapy, as it is now possible for the first time to study the genetic causes of diseases. It should thus be possible in due course to treat the causes rather than the symptoms. High-throughput sequencing will probably become a routine diagnostic, which will allow personalized medical treatment. Opportunities open up for the biotech industry (**red biotechnology**) to develop new diagnostics and therapeutics such as recombinant hormones, enzymes, antigens, vaccines, and antibodies that were not available before the genetic revolution. In the field of **green biotechnology**, targeted modification of crop cultivars can improve their properties, such as resistance to pests or the synthesis of new products (including recombinant human proteins). In **microbial biotechnology**, production processes can be improved and new products can be created through combinatorial biosynthesis.

The term **molecular biotechnology** also covers state-of-the-art research in genomics, functional genomics, proteomics, transcriptomics, systems biology, gene therapy, or molecular diagnostics. The concepts and methods are derived from cell and molecular biology, structural biology, bioinformatics, and biophysics.

The success of molecular biotechnology has been considerable, if you look at the scientific and economic prowess of companies like Genentech, Biogen, and



others. Already today total annual revenues from recombinant drugs exceeds US \$ 20 billion. Over 100 recombinant proteins have been approved by the US Food and Drug Administration and several hundred others are in the developmental pipeline.

As textbooks covering this extensive subject are few, a group of experts and university teachers decided to write an introductory textbook that looks at a wide variety of aspects. This is the English language version of the second edition of *An Introduction to Molecular Biotechnology*, which has been thoroughly updated, a new chapter on systems biology has been added (Chapter 23), and many illustrations are now in color.

The comprehensive introductory chapters (*Part I*) provide a brief compendium of the essential building blocks and processes in a cell, their structure, and functions. This information is crucial for the understanding of the following chapters, and while it cannot be a substitute for the profound study of more substantial and extensive textbooks on cell and molecular biology (Alberts *et al.*, 2008; Campbell and Reece, 2006), it gives a quick overview and recapitulation.

*Part II* contains short chapters discussing the most important methods used in biotechnology. Again, for a more thorough approach to the subject, consult the relevant textbooks.

*Part III* explores the different fields of molecular biotechnology, such as genome research, functional genomics, proteomics, transcriptomics, bioinformatics, systems biology, gene therapy, and molecular diagnostics. It not only gives a summary of current knowledge, but also highlights future applications and developments.

*Part IV* discusses the industrial environment of molecular biotechnology, including the business environment and difficulties young biotech firms have to cope with and their chances of success.

To give a snapshot of state-of-the-art research in an area where things move faster than anywhere else is next to impossible. Thus, it is inevitable that by the time this book goes into print, some developments will have superseded those described here. Although we have tried to include most relevant issues, the choice of topics must naturally be limited in a such a textbook.

Forty-two coauthors worked on this project, and although we tried to find a more or less uniform style, the authors with their different views and values are still recognizable.

The publisher and editors would like to thank all authors for their constructive cooperation. Special thanks go to the team at Wiley-VCH (Dr. A. Sendtko, M. Petersen, H.-J. Schmitt) who gave their enthusiastic support to this project.

Heidelberg, Winter 2011

Michael Wink

## List of Contributors

Michael Breuer  
BASF SE  
Fine Chemicals & Biocatalysis  
Research  
GVF/B – A030  
67056 Ludwigshafen  
Germany

Benedikt Brors  
German Cancer Research Center  
Computational Oncology  
Im Neuenheimer Feld 580  
69120 Heidelberg  
Germany

Ulrich Deuschle  
Phenex Pharmaceuticals AG  
Waldhofer Str. 104  
69123 Heidelberg  
Germany

Stephan Diekmann  
Leibniz Institute for Age Research  
Fritz Lipmann Institute  
Beutenbergstraße 11  
07745 Jena  
Germany

Stefan Dübel  
Institute for Biochemistry  
and Biotechnology  
Technical University of Braunschweig  
Spielmannstr. 7  
38106 Braunschweig  
Germany

Rainer Fink  
Institute for Physiology  
and Pathophysiology  
University of Heidelberg  
Im Neuenheimer Feld 326  
69120 Heidelberg  
Germany

Gert Fricker  
Institute of Pharmacy  
and Molecular Biotechnology  
University of Heidelberg  
Im Neuenheimer Feld 366  
69120 Heidelberg  
Germany

Marcus Frohme  
Molecular Biology  
and Functional Genomics  
Technical University of Applied  
Sciences  
Bahnhofstraße  
15745 Wildau  
Germany

Reinhard Gessner  
Visceral, Transplantation, Thorax  
and Vascular Surgery  
University Hospital Leipzig  
Liebigstr. 20  
04103 Leipzig  
Germany

Ariane Groth  
General, Visceral and Transplantation  
Surgery  
Molecular OncoSurgery  
University Hospital Heidelberg  
Im Neuenheimer Feld 365  
69120 Heidelberg  
Germany

Bernhard Hauer  
Institute of Technical Biochemistry  
University of Stuttgart  
Allmandring 31  
70569 Stuttgart  
Germany

Rüdiger Hell  
Heidelberg Institute of Plant Sciences  
University of Heidelberg  
Im Neuenheimer Feld 360  
69120 Heidelberg  
Germany

Ingrid Herr  
General, Visceral and Transplantation  
Surgery  
Molecular OncoSurgery  
University Hospital Heidelberg  
Im Neuenheimer Feld 365  
69120 Heidelberg  
Germany

Helke Hillebrand  
European Molecular Biology  
Laboratory (EMBL)  
Meyerhofstr. 1  
69117 Heidelberg  
Germany

Ana Kitanovic  
Institute for Pharmacy & Molecular  
Biotechnology  
University of Heidelberg  
Im Neuenheimer Feld 364  
69120 Heidelberg  
Germany

Manfred Koegl  
Boehringer Ingelheim Vienna  
Oncology Research  
Dr. Boehringer Gasse 5–11  
1121 Vienna  
Austria

Rainer König  
Institute of Pharmacy and  
Molecular Biotechnology  
University of Heidelberg Bioquant  
Im Neuenheimer Feld 267  
69120 Heidelberg  
Germany

Robert Kraft  
Carl Ludwig Institute of Physiology  
University of Leipzig  
Liebigstr. 27  
04113 Leipzig  
Germany

Claus Kremoser  
PheneX Pharmaceuticals AG  
Im Neuenheimer Feld 515  
69120 Heidelberg  
Germany

Stefan Legewie  
Institute of Molecular Biology  
Ackermannweg 4  
55128 Mainz  
Germany

Wolf-Dieter Lehmann  
German Cancer Research Center  
Molecular Structure Analysis  
Mass Spectroscopy  
Im Neuenheimer Feld 280  
69120 Heidelberg  
Germany

Susanne Lutz  
Institute of Experimental and Clinical  
Pharmacology and Toxicology  
University of Heidelberg  
Maybachstraße 14  
68169 Mannheim  
Germany

Nils Metzler-Nolte  
Chair of Inorganic Chemistry I  
Bioinorganic Chemistry  
Ruhr-University of Bochum  
Universitätsstr. 150  
44801 Bochum  
Germany

Andrea Mohr  
National Center for Biomedical  
Engineering Science  
National University of Ireland  
University Road  
Galway  
Ireland

Ehmke Pohl  
Department of Chemistry & School  
of Biological and  
Biomedical Sciences  
Durham University  
Durham, DH1 3LE  
Great Britain

David B. Resnik  
National Institute of Environmental  
Health Science  
National Institutes of Health  
111 T.W. Alexander Drive  
Research Triangle Park, NC 27709  
USA

Andreas Schlosser  
Center for Biological Systems  
Analysis (ZBSA)  
University of Freiburg  
Habsburgerstr. 49  
79104 Freiburg  
Germany

Hannah Schmidt-Glenewinkel  
German Cancer Research Center  
Theoretical Systems Biology  
Im Neuenheimer Feld 280  
69120 Heidelberg  
Germany

Julia Schüler  
BioMedServices  
Hecker-Str. 20  
68199 Mannheim  
Germany

Anna Sosniak  
Chair of Inorganic Chemistry I  
Bioinorganic Chemistry  
University of Bochum  
Universitätsstr. 150  
44801 Bochum  
Germany

Rolf Sprengel  
Max Planck Institute  
for Medical Research  
Jahnstrasse 29  
69120 Heidelberg  
Germany

Ralf Tolle  
Center for Molecular Biology (ZMBH)  
University of Heidelberg  
Im Neuenheimer Feld 282  
69120 Heidelberg  
Germany

Peter Uetz  
Delaware Biotechnology Institute  
University of Delaware  
15 Innovation Way  
Newark, DE 19711-5449  
USA

Martin Vogel  
Max Planck Institute of Biophysics  
Max-von-Laue-Str. 3  
60438 Frankfurt  
Germany

Gary Walsh  
Department of Chemical &  
Environmental Sciences  
Plassey Park  
University of Limerick  
Limerick  
Ireland

Hans Weiher  
Bonn-Rhein-Sieg University  
of Applied Sciences  
Department of Natural Sciences  
Von-Liebig-Str. 20  
53359 Rheinbach  
Germany

Thomas Wieland  
Institute of Experimental and Clinical  
Pharmacology and Toxicology  
University of Heidelberg  
Maybachstraße 14  
68169 Mannheim  
Germany

Stefan Wiemann  
German Cancer Research Center  
Molecular Genome Analysis  
Im Neuenheimer Feld 580  
69120 Heidelberg  
Germany

Michael Wink  
Institute of Pharmacy and Molecular  
Biotechnology  
University of Heidelberg  
Im Neuenheimer Feld 364  
69120 Heidelberg  
Germany

Stefan Wölfl  
Institute for Pharmacy & Molecular  
Biotechnology  
University of Heidelberg  
Im Neuenheimer Feld 364  
69120 Heidelberg  
Germany

Ralf Zwacka  
National Center for Biomedical  
Engineering Science  
National University of Ireland  
University Road  
Galway  
Ireland



## Abbreviations

1 Å	=0.1 nm
aa-tRNA	aminoacyl-tRNA
AAV	adeno-associated virus
ABC	ATP binding cassette
Acetyl-CoA	acetyl coenzyme A
AcNPV	<i>Autographa californica</i> nuclear polyhedrosis virus
ACRS	amplification-created restriction sites
ACTH	adrenocorticotrophic hormone
ADA	adenosine deaminase
ADEPT	antibody-directed enzyme pro-drug therapy
ADME-T	absorption, distribution, metabolism, excretion and toxicity
ADP	adenosine diphosphate
ADRs	adverse drug reactions
AEC	aminoethylcysteine
AFLP	amplified fragment length polymorphism
AFM	atomic force microscope
AIDS	acquired immune deficiency syndrome
ALS	amyotrophic lateral sclerosis
AMP	adenosine monophosphate
AMPA	$\alpha$ -amino-3-hydroxyl-5-methyl-4-isoxazol-propionate
Amp <sup>r</sup>	ampicillin resistance gene
AMV	avian myeloblastosis virus
ANN	artificial neural network
AO	acridine orange
AOX1	alcohol oxidase 1
APC	anaphase promoting complex
ApoB100	apolipoprotein B100
ApoE	apolipoprotein E
APP	amyloid precursor protein
ARMS	amplification refractory mutation system
ARS	autonomously replicating sequence
ATP	adenosine triphosphate
att	attachment site
BAC	bacterial artificial chromosome
bcl2	B-cell leukemia lymphoma 2 (protein protecting against apoptosis)
BfArM	German Bundesinstitut für Arzneimittel und Medizinprodukte
$\beta$ -Gal	$\beta$ -galactosidase
BHK-21	baby hamster kidney cells
BLA	biologics licence application
BLAST	basic local alignment search tool
BMP	bone morphogenetic proteins
bp	base pairs
BrdU	bromodeoxyuridine

CA	correspondence analysis
CAD	coronary artery disease
CaM-Kinase	Ca <sup>2+</sup> /calmodulin-dependent protein kinase
cAMP	cyclic AMP
cap	AAV gene mediating encapsulation
CARS	coherent anti-Raman scattering
CAT	Committee for Advanced Therapies
CBER	Center for Biologics Evaluation and Research
CC	chromatin remodelling complex
CCD	charge-coupled device
CDER	Center for Drug Evaluation and Research
CDK	cyclin-dependent kinase
cDNA	copy DNA
CDR	complementary determining region
CDRH	Center for Devices and Radiological Health
CEO	chief executive officer
CFP	cyan fluorescent protein
CFTR	cystic fibrosis transmembrane regulator
CGAP	cancer genome anatomy project
CGH	comparative genome hybridization
CHMP	Committee for Medicinal Products for Human Use
CHO	Chinese hamster ovary
CIP	calf intestinal phosphatase
CML	chronic myeloid leukemia
CMN	<i>Corynebacterium-Mycobacterium-Nocardia</i> group
CMV	cauliflower mosaic virus
CMV	Cytomegalovirus
CNS	central nervous system
COMP	Committee on Orphan Medicinal Products
COS-1	simian cell line, CV-1, transformed by origin-defective mutant of SV40
cpDNA	chloroplast DNA
CPMV	cowpea mosaic virus
cPPT-sequence	central polypurine tract – regulatory element in lentiviral vectors that facilitates double strand synthesis and the nuclear import of the pre-integration complex
CSF	colony-stimulating factor
CSO	contract service organisation
CTAB	cetyltrimethylammonium bromide
CVM	Center for Veterinary Medicine
CVMP	Committee for Medicinal Products for Veterinary Use
2D	two-dimensional
Da	Dalton
DAG	diacylglycerol
DAPI	4,6-diamidino-2-phenylindole
dATP	deoxyadenosine triphosphate
DBD	DNA-binding domain
DAC	divide-and-conquer strategy
DD	differential display
DDBJ	DNA Data Bank of Japan
ddNTP	dideoxynucleotide triphosphate
DEAE	diethylaminoethyl
dHPLC	denaturing HPLC
DIC	differential interference contrast
DIP	Database of Interacting Proteins
DNA	deoxyribonucleic acid
DNAse	deoxyribonuclease

dNTP	deoxynucleoside triphosphate
Dox	doxycycline
ds diabodies	disulfide-stabilized diabodies
dsDNA	double-stranded DNA
dsFv-fragment	disulfide-stabilized Fv fragment
dsRNA	double-stranded RNA
DtxR	diphtheria toxin repressor
Ebola-Z	envelope protein of the Ebola-Zaire virus, which has a high affinity to lung epithelial cells
EC <sub>50</sub>	effective concentration, the dose or concentration that produces a 50% effect in the test population within a specified time
ECD	electron capture dissociation
EDTA	ethylenediaminetetraacetic acid
ee	enantiomeric excess
EF2	elongation factor 2
EF-Tu	elongation factor Tu
EGF	epidermal growth factor
EGFP	enhanced green fluorescent protein
EGTA	ethyleneglycol-bis-(2-aminoethyl)-tetraacetic acid
EIAV	equine infectious anaemia virus
ELISA	enzyme-linked immunosorbent assay
EM	electron microscope
EMA	European Medicines Agency
EMBL	European Molecular Biology Laboratory
EMCV	Encephalomyocarditis virus
EMSA	electrophoretic mobility shift assay
EMA	European Agency for the Evaluation of Medicinal Products
ENU	N-ethyl-N-nitrosourea
env	retroviral gene coding for viral envelope proteins
EPO	European Patent Office
EPR effect	enhanced permeability and retention effect
EPC	European Patent Convention
ER	endoplasmic reticulum
ESI	electrospray ionization
EST	expressed sequence tags
ES cells	embryonic stem cells
EtBr	ethidium bromide
Fab-fragment	antigen binding fragment
FACS	fluorescence-activated cell sorter
FAD	flavin adenine dinucleotide
FBA	flux balance analysis
FCS	fluorescence correlation spectroscopy
FDA	Food and Drug Administration
FFL	feed-forward loop
FGF	fibroblast growth factor
FISH	fluorescence in situ hybridization
FIV	feline immunodeficiency virus
FKBP	FK506-binding protein
FLIM	fluorescence lifetime imaging microscopy
FLIPR	fluorescent imaging plate reader
FMN	flavin mononucleotide
FPLC	fast performance liquid chromatography
FRAP	fluorescence recovery after photobleaching
FRET	fluorescence resonance energy transfer
FT-ICR	Fourier transformation cyclotron resonance, method in mass spectroscopy

FtsZ	prokaryotic cell division protein
Fur	ferric uptake regulator
Fv-fragment	variable fragment
FWHM	full width at half maximum
GABA	gamma aminobutyric acid
Gag	retroviral gene coding for structural proteins
Gal	galactose
GAP	GTPase-activating protein
GAPDH	glyceraldehyde 3-phosphate-dehydrogenase
Gb	Gigabases
GCC	German cDNA consortium
GCG	genetics computer group
GCP	good clinical practice
$\Delta G_d$	free enthalpy
GDH	glutamate dehydrogenase
GDP	guanosine diphosphate
GEF	guanine exchange factor
GEO	gene expression omnibus
GFP	green fluorescence protein
GM-CSF	granulocyte/macrophage colony-stimulating factor
GO	gene ontology
GOI	gene of interest
GPCR	G-protein-coupled receptor
GPI anchor	glycosylphosphatidylinositol anchor
GRAS	generally regarded as safe
GST	glutathione-S-transferase
GTC	guanidinium isothiocyanate
GTP	guanosine triphosphate
GUS	glucuronidase
GMO	genetically modified organism
HA	hemagglutinin
HCM	hypertrophic cardiomyopathy
HCV	Hepatitis C virus
HEK	human embryonic kidney
HeLa cells	human cancer cell line (isolated from donor Helene Larsen)
HER 2	human epidermal growth factor 2
HGH	human growth hormone
HIC	hydrophobic interaction chromatography
His <sub>6</sub>	hexahistidine tag
HIV	human immunodeficiency virus, a retrovirus
HIV 1	human immunodeficiency virus 1
HLA	human leukocyte antigen
hnRNA	heterogeneous nuclear RNA
HPLC	high performance liquid chromatography
HPT	hygromycin phosphotransferase
HPV	human papilloma virus
HSP	high-scoring segment pairs
HSP	heat shock protein
HSV-1	Herpes simplex virus
HTS	high-throughput analysis
HUGO	Human Genome Organisation
HV	Herpes virus
IAS	international accounting standard
ICDH	isocitric dehydrogenase

ICH	International Conference on Harmonization of Technical Requirements for the Registration of Pharmaceuticals for Human Use
ICL	isocitric lyase
ICP-MS	inductively coupled-plasma mass spectrometry
ICR-MS	ion cyclotron resonance mass spectrometer
IDA	iminodiacetic acid
IEF	isoelectric focusing
Ig	immunoglobulin
IHF	integration host factor
IMAC	immobilized metal affinity chromatography
IND-Status	investigational new drug status
IP <sub>3</sub>	inositol-1,4,5-triphosphate
IPO	initial public offering
IPTG	isopropyl-b-D-thiogalactoside
IR	inverted repeats
IR	investor relations
IRES	internal ribosome entry site
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
ISH	in situ hybridization
ISSR	inter simple sequence repeats
ITC	isothermal titration calorimetry
ITR	inverse terminal repeats – regulatory elements in adenoviruses and AAV
i.v.	intravenous
k <sub>a</sub>	second order velocity constant in bimolecular association
Kan <sup>r</sup>	kanamycin resistance gene
K <sub>av</sub>	specific distribution coefficient
kb	Kilobases
k <sub>d</sub>	first order velocity constant in unimolecular dissociation
K <sub>d</sub> =k <sub>d</sub> /k <sub>a</sub>	velocity constant in dissociation/K <sub>a</sub> in association
kDa	Kilodalton
KDEL	amino acid sequence for proteins remaining in the ER
KDR receptor	kinase insert domain containing receptor
KEGG	Kyoto Encyclopedia of Genes and Genomes
Lac	lactose
LASER	Light Amplification by Stimulated Emission of Radiation
LB	left border
LB	Luria-Bertani medium
LCR	ligation chain reaction
LDL	low-density-lipoprotein
LIMS	laboratory information management systems
LINE	long interspersed elements
LSC	Laser scanning-cytometer
LTQ	linear trap quadrupole
LTQ-FT-ICR	linear trap quadrupole-Fourier transformation-ion cyclotron resonance
LTR	long terminal repeats; regulatory elements in retroviruses
LUMIER	LUMInescence-based mammalian intERactome
MAC	mammalian artificial chromosome
mAChR	muscarinic acetylcholine receptor
MAGE-ML	microarray gene expression markup language
MALDI	matrix-assisted laser desorption/ionization
6-MAM	6-monoacetylmorphine
MAP	microtubule-associated protein
MAP	mitosis-activating protein

Mb	Megabases
MBP	maltose-binding protein
MCS	multiple cloning site
M-CSF	macrophage colony-stimulating factor
MDR protein	multiple drug resistance protein
MDS	multidimensional scaling
MGC	mammalian gene collection
MHC	major histocompatibility complex
MIAME	minimum information about a microarray experiment
miRNA	microRNA
MIT	Massachusetts Institute of Technology
MoMLV	moloney murine leukemia virus
Mowse	molecular weight search
MPF	M-phase promotion factor
MPSS	massively parallel signature screening
Mreb/Mbl	proteins of prokaryotic cytoskeleton
mRNA	messenger RNA
MRSA	methicillin-resistant <i>S. aureus</i>
MS	mass spectrometry
MSG	monosodium glutamate
MS-PCR	mutationally separated PCR
MTA	material transfer agreement
mtDNA	mitochondrial DNA
MULVR	Moloney Murine Leukemia Virus
MW	molecular weight
$\mu$ F	$\mu$ Farad
nAChR	nicotinic acetylcholine receptor
NAD	nicotinamide adenine dinucleotide
NAPPA	nucleic acid programmable protein array
NCBI	National Center for Biotechnology Information
NDA	new drug application
NDP	nucleoside diphosphate
NDPK	nucleoside diphosphates kinase
NFjB	nuclear factor jB
NIH	National Institutes of Health
NK cell	natural killer cell
NMDA-receptor	N-methyl-D-aspartate-receptor
NMR	nuclear magnetic resonance
NPTII	neomycin phosphotransferase II
NSAID	non-steroidal anti-inflammatory drug
NTA	nitrilotriacetic acid
NTP	nucleoside triphosphate
OD	optical density
ODE	ordinary differential equation
ODHC	2-oxoglutarate dehydrogenase
OMIM	online Mendelian inheritance in man
ORF	open reading frame
ori	origin of replication
OXA complex	membrane translocator in mitochondria
PAC	P1-derived artificial chromosome
PAGE	polyacrylamide-gel electrophoresis
PAZ-domain	<i>PIWI Argonaute Zwillie domain</i>
PCA	principal component analysis
PCR	polymerase chain reaction
PDB	protein data bank
PEG	polyethylene glycol
PFAM	protein families database of alignments and HMMs



PFG	pulsed-field gel electrophoresis
PI	propidium iodide
PIR	protein information resource
piRNA	piwi-interacting RNA
PKA	protein kinase A
PKC	protein kinase C
PK data	pharmacokinetic data
Plos	Public Library of Science
PMSF	phenylmethylsulfonyl fluoride
PNA	peptide nucleic acid
PNGaseF	peptide N-glycosidase F
PNK	T4-polynucleotide kinase
pol	retroviral gene coding for reverse transcriptase and integrase
P <sub>PH</sub>	polyhedrin promoter
PR	Public Relations
psi	retroviral packaging signal
PTGS	posttranscriptional gene silencing
PTI	pancreatic trypsin inhibitor
Q-FT-ICR	Q-Fourier transform ion cyclotron resonance
Q-TOF	Quadrupole-Time-of-Flight
RACE	rapid amplification of cDNA ends
Ran	protein involved in nuclear import
RAPD	random amplification of polymorphic DNA
RAP-PCR	RNA arbitrary primed PCR
RB	right border
RBD	RNA-binding domain
Rb-gene	retinoblastoma gene
RBS	ribosome binding site
RDA	representative difference analysis
RdRp	RNA-dependent RNA polymerase
rep	AAV gene, mediating replication
RES	reticuloendothelial system
RFLP	restriction fragment length polymorphism
Rf-value	retention factor
RGS	regulator of G-protein signaling
RISC	RNA-induced silencing complex
RNA	ribonucleic acid
RNAi	RNA interference
RNP	ribonucleoprotein
rpm	revolutions per minute
RRE	regulatory element in a lentiviral vector, enhancing the nuclear export of viral RNA
rRNA	ribosomal RNA
RSV	respiratory syncytial virus
RSV	promoter of the Rous sarcoma virus
RT	reverse transcriptase
rtTA	tetracyclin-sensitive regulatory unit
SAGE	Serial Analysis of Gene Expression
SALM	spectrally assigned localization microscopy
SAM	S-adenosylmethionine
sc diabodies	single-chain diabodies
scFab	single-chain Fab-fragment
scFv/sFv fragment	single-chain Fv fragment
SCID	severe combined immunodeficiency
SCOP	structural classification of proteins
SDS	sodium dodecyl sulfate

SDS-PAGE	sodium dodecyl sulfate polyacrylamide gel electrophoresis
SELEX	systematic evolution of ligand by exponential enrichment
SEM	scanning electron microscope
Sf cells	<i>Spodoptera frugiperda</i> cells
SFM	scanning force microscope
SFV	Semliki-Forest virus
SH1	Src-homology domain 1=kinase domain
SH2	Src-homology domain 2
SH3	Src-homology domain 3
SHG	second harmonic generation
SIM	single input
SIN	self-inactivating lentiviral vectors, due to a 3' LTR mutation
SINE	scattered or short interspersed elements
siRNA	small interfering RNA
SIV	simian immunodeficiency virus
SNARE proteins	SNAP-receptor proteins
SNP	single nucleotide polymorphism
snRNA	small nuclear RNA
snRNP	small nuclear ribonucleoprotein
SOP	stock option program
SP function	sum-of-pairs function
SPA	scintillation proximity assay
SPDM	spectral precision distance microscopy
SPF	S-phase promotion factor
SRP	signal recognition particle
SSB	single strand binding proteins
SSCP	single-strand conformation polymorphism
ssDNA	single-stranded DNA
SSH	suppressive subtractive hybridization
SssI methylase	methylase from <i>Spiroplasma</i>
ssRNA	single-stranded RNA
STED	stimulated emission depletion
STEM	scanning transmission electron microscope
stRNA	small temporal RNA
STS	sequence-tagged site
SV40	Simian-virus-type 40
TBP	TATA-binding protein
T <sub>C</sub>	cytotoxic T-cells
Tc	tetracycline
T-DNA	transfer DNA
TEM	transmission electron-microscope
TEV	Tobacco Etch Virus
T <sub>H</sub>	T helper cell
THG	third harmonic generation
TIGR	The Institute for Genome Research
TIM	translocase of inner membrane
T <sub>m</sub>	melting temperature of dsDNA
TNF	tumor necrosis factor
TOF	time of flight
TOM	translocase of outer membrane
t-PA	tissue plasminogen activator
TRE	tetracycline-responsive element
TRIPs	Trade-Related Aspects of Intellectual Property Rights
tRNA	transfer RNA
Trp	tryptophan
t-SNARE	protein in target membrane to which vSNARE binds
TSS	transformation and storage solution

tTA	tetracycline-controlled transactivator
TY	transposon from yeast
UPOV	Union for the Protection of New Varieties of Plants
US-GAAP	US generally accepted accounting principle
UV	ultraviolet
V <sub>0</sub>	empty volume
VC	venture capital
V <sub>e</sub>	elution volume
VEGF	vascular endothelial growth factor
VIP	vasoactive peptide
VNTR	variable number tandem repeats
v-SNARE	protein in vesicular membrane, binding to t-SNARE
VSV-G	envelope protein of vesicular stomatitis virus, great affinity to a wide range of cells
V <sub>t</sub>	total volume
wNAPPA	modified nucleic acid programmable protein array
WPRE	woodchuck hepatitis virus posttranscriptional regulatory element
X-Gal	5-bromo-4-chloro-3-indolyl-b-D-galactopyranoside
YAC	yeast artificial chromosome
YE <sub>p</sub>	yeast episomal plasmid
YFP	yellow fluorescence protein
YIp	yeast-integrating plasmid
YRp	yeast-replicating plasmid
Yth	yeast two-hybrid