**COLD SPRING HARBOR SYMPOSIA
ON QUANTITATIVE BIOLOGY
VOLUME LXXXI**

symposium.cshlp.org

Online access: Please visit our companion website at symposium.cshlp.org. For access questions, please contact Cold Spring Harbor Laboratory Press at subscriptions@cshl.edu.

COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY

VOLUME LXXXI

Targeting Cancer

symposium.cshlp.org

Symposium Organizers: Scott Lowe (*Memorial Sloan Kettering Cancer Center*),
Kornelia Polyak (*Dana-Farber Cancer Institute*),
David Stewart and Bruce Stillman (*Cold Spring Harbor Laboratory*),
and Eileen White (*The Rutgers Cancer Institute of New Jersey*)

Editors: David Stewart and Bruce Stillman (*Cold Spring Harbor Laboratory*)

COLD SPRING HARBOR LABORATORY PRESS
2016

COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY VOLUME LXXXI

© 2016 by Cold Spring Harbor Laboratory Press

International Standard Book Number 978-1-621822-09-7 (cloth)

International Standard Book Number 978-1-621822-10-3 (paper)

International Standard Serial Number 0091-7451

Library of Congress Catalog Card Number 34-8174

Printed in the United States of America

All rights reserved

COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY

Founded in 1933 by

REGINALD G. HARRIS

Director of the Biological Laboratory 1924 to 1936

Previous Symposia Volumes

I (1933) Surface Phenomena	XL (1975) The Synapse
II (1934) Aspects of Growth	XLI (1976) Origins of Lymphocyte Diversity
III (1935) Photochemical Reactions	XLII (1977) Chromatin
IV (1936) Excitation Phenomena	XLIII (1978) DNA: Replication and Recombination
V (1937) Internal Secretions	XLIV (1979) Viral Oncogenes
VI (1938) Protein Chemistry	XLV (1980) Movable Genetic Elements
VII (1939) Biological Oxidations	XLVI (1981) Organization of the Cytoplasm
VIII (1940) Permeability and the Nature of Cell Membranes	XLVII (1982) Structures of DNA
IX (1941) Genes and Chromosomes: Structure and Organization	XLVIII (1983) Molecular Neurobiology
X (1942) The Relation of Hormones to Development	XLIX (1984) Recombination at the DNA Level
XI (1946) Heredity and Variation in Microorganisms	L (1985) Molecular Biology of Development
XII (1947) Nucleic Acids and Nucleoproteins	LI (1986) Molecular Biology of Homo sapiens
XIII (1948) Biological Applications of Tracer Elements	LII (1987) Evolution of Catalytic Function
XIV (1949) Amino Acids and Proteins	LIII (1988) Molecular Biology of Signal Transduction
XV (1950) Origin and Evolution of Man	LIV (1989) Immunological Recognition
XVI (1951) Genes and Mutations	LV (1990) The Brain
XVII (1952) The Neuron	LVI (1991) The Cell Cycle
XVIII (1953) Viruses	LVII (1992) The Cell Surface
XIX (1954) The Mammalian Fetus: Physiological Aspects of Development	LVIII (1993) DNA and Chromosomes
XX (1955) Population Genetics: The Nature and Causes of Genetic Variability in Population	LVIX (1994) The Molecular Genetics of Cancer
XXI (1956) Genetic Mechanisms: Structure and Function	LX (1995) Protein Kinesis: The Dynamics of Protein Trafficking and Stability
XXII (1957) Population Studies: Animal Ecology and Demography	LXI (1996) Function & Dysfunction in the Nervous System
XXIII (1958) Exchange of Genetic Material: Mechanism and Consequences	LXII (1997) Pattern Formation during Development
XXIV (1959) Genetics and Twentieth Century Darwinism	LXIII (1998) Mechanisms of Transcription
XXV (1960) Biological Clocks	LXIV (1999) Signaling and Gene Expression in the Immune System
XXVI (1961) Cellular Regulatory Mechanisms	LXV (2000) Biological Responses to DNA Damage
XXVII (1962) Basic Mechanisms in Animal Virus Biology	LXVI (2001) The Ribosome
XXVIII (1963) Synthesis and Structure of Macromolecules	LXVII (2002) The Cardiovascular System
XXIX (1964) Human Genetics	LXVIII (2003) The Genome of Homo sapiens
XXX (1965) Sensory Receptors	LXIX (2004) Epigenetics
XXXI (1966) The Genetic Code	LXX (2005) Molecular Approaches to Controlling Cancer
XXXII (1967) Antibodies	LXXI (2006) Regulatory RNAs
XXXIII (1968) Replication of DNA in Microorganisms	LXXII (2007) Clocks and Rhythms
XXXIV (1969) The Mechanism of Protein Synthesis	LXXIII (2008) Control and Regulation of Stem Cells
XXXV (1970) Transcription of Genetic Material	LXXIV (2009) Evolution: The Molecular Landscape
XXXVI (1971) Structure and Function of Proteins at the Three-dimensional Level	LXXV (2010) Nuclear Organization and Function
XXXVII (1972) The Mechanism of Muscle Contraction	LXXVI (2011) Metabolism and Disease
XXXVIII (1973) Chromosome Structure and Function	LXXVII (2012) The Biology of Plants
XXXIX (1974) Tumor Viruses	LXXVIII (2013) Immunity and Tolerance
	LXXIX (2014) Cognition
	LXXX (2015) 21st Century Genetics: Genes at Work

Front cover (paperback): Robert Delaunay, *Circular Forms (Formes circulaires)*, 1930, oil on canvas, 50 3/4 × 76 3/4 inches (128.9 × 194.9 cm), Solomon R. Guggenheim Museum, New York, Solomon R. Guggenheim Founding Collection 49.1184.

Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Cold Spring Harbor Laboratory Press, provided that the appropriate fee is paid directly to the Copyright Clearance Center (CCC). Write or call CCC at 222 Rosewood Drive, Danvers, MA 01923 (978-750-8400) for information about fees and regulations. Prior to photocopying items for educational classroom use, contact CCC at the above address. Additional information on CCC can be obtained at CCC Online at www.copyright.com.

For a complete catalog of all Cold Spring Harbor Laboratory Press publications, visit our website www.cshlpress.org.

Online access: Please visit our companion website at symposium.cshlp.org. For access issues, please contact Cold Spring Harbor Laboratory Press at subscriptions@cshl.edu.

Symposium Participants

- ABBRUZZESE, GENEVIEVE, Massachusetts Institute of Technology, Cambridge, Massachusetts
- AKRE, MONICA, University of Minnesota, Minneapolis, Minnesota
- ALAGESAN, BRINDA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- ALBANESE, CHRISTINA, Rensselaer Polytechnic Institute, Troy, New York
- ALBREGUES, JEAN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- ALDERTON, GEMMA, *Nature Reviews Cancer*, London, United Kingdom
- ALEXANDROVA, EVGUENIA, Stony Brook University, Stony Brook, New York
- ALONSO CURBELO, DIRENA, Memorial Sloan Kettering Cancer Center, New York, New York
- ALVANIA, REBECCA, Rockefeller University Press, New York, New York
- ALZRIGAT, MOHAMMAD, Uppsala University, Uppsala, Sweden
- AMBRICO, ALEXANDRA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- AMELIO, ANTONIO, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
- AMON, ANGELIKA, Massachusetts Institute of Technology, Cambridge, Massachusetts
- ANCZUKOW, OLGA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- ANTAL, CORINA, Salk Institute, La Jolla, California
- ARANDA, VICTORIA, *Nature*, New York, New York
- ARDITO-ABRAHAM, CHRISTINE, Lustgarten Foundation, Bethpage, New York
- ARMSTRONG, SCOTT, Memorial Sloan Kettering Cancer Center, New York, New York
- ARUN, GAYATRI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- ATRETKHANY, KAMAR-SULU, Engelhardt Institute of Molecular Biology, Moscow, Russia
- AYENI, DEBORAH, Yale University, New Haven, Connecticut
- AZZOPARDI, STEPHANIE, Weill Cornell Medical College, New York, New York
- BAKER, LINDSEY, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- BAKHOUM, SAMUEL, Memorial Sloan Kettering Cancer Center, New York, New York
- BENEVOLENSKAYA, ELIZAVETA, University of Illinois at Chicago, Chicago, Chicago
- BERGERS, GABRIELE, University of California, San Francisco, San Francisco, California
- BEVERLY, LEVI, University of Louisville, Louisville, Kentucky
- BHOLA, PATRICK, Dana-Farber Cancer Institute, Boston, Massachusetts
- BIFFI, GIULIA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- BIKFALVI, ANDREAS, INSERM and University Bordeaux, Pessac, France
- BISWAS, ROMI, National Institutes of Health, Bethesda, Maryland
- BLAIN, STACY, State University of New York Downstate Medical Center, Brooklyn, New York
- BLASCO, MARIA, Spanish National Cancer Research Center, Madrid, Spain
- BOSBACH, BENEDIKT, Memorial Sloan Kettering Cancer Center, New York, New York
- BOSE, ROHIT, Memorial Sloan Kettering Cancer Center, New York, New York
- BOYE, KEVIN, INSERM and Bordeaux University, Pessac, France
- BRADY, COLLEEN, *Cancer Cell*, Cambridge, Massachusetts
- BRISARD, DAPHNE, Northwestern University, Chicago, Illinois
- BRUGGE, JOAN, Harvard Medical School, Boston, Massachusetts
- BRUZAS, EMILIS, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- BUDMAN, DANIEL, Northwell Health, Lake Success, New York
- BURGER, MEGAN, Massachusetts Institute of Technology, Cambridge, Massachusetts
- BURGOS-BARRAGAN, GUILLERMO, University of Cambridge, Cambridge, United Kingdom
- CALDAS, CARLOS, Cancer Research UK Cambridge Institute, Cambridge, United Kingdom
- CAMPBELL, ROBERT, Brown University, Providence, Rhode Island
- CANNER, DAVID, Massachusetts Institute of Technology, Cambridge, Massachusetts
- CAO, ZHEN, Memorial Sloan Kettering Cancer Center, New York, New York
- CARBINI, MARIANA, Italy
- CARUGO, ALESSANDRO, University of Texas MD Anderson Cancer Center, Houston, Texas
- CARVALHO, TIAGO, Rockefeller University, New York, New York
- CASANOVA, IRENE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- CASPER, KAREN, Washington Technology School, Roseville, Minnesota
- CHA, ADRIEL, Stanford University, Stanford, California
- CHAKRABORTY, ABHISHEK, Dana-Farber Cancer Institute, Boston, Massachusetts
- CHALLA, SRIDEVI, H. Lee Moffitt Cancer Center, Tampa, Florida
- CHANG, KUNG-CHI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- CHEN, CHONG, Sichuan University, Chengdu, China
- CHEN, HSIAO-CHI, National Yang-Ming University, Taipei, Taiwan
- CHEN, LIANG, Duke University, Durham, North Carolina
- CHEN, SIDI, Yale University, West Haven, Connecticut
- CHEN, YUNCHING, National Tsing Hua University, Hsinchu, Taiwan
- CHEON, DONG-JOO, Albany Medical College, Albany, New York
- CHEUNG-ONG, KAHLIN, Onkaido Therapeutics, Cambridge, Massachusetts
- CHI, MAOYEN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- CHIANG, CHENG-MING, UT Southwestern Medical Center, Dallas, Texas
- CHIO, CHRISTINE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- CHOI, SOYOUNG, Weill Cornell Medical College, New York, New York
- CHOWDHURY, A.M. MASUDUL AZAD, Doshisha University, Kyotanabe, Japan
- CHUANG, CHEN-HUA, Stanford University, Mountain View, California
- CHUNG, TAE MUN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- CICHOWSKI, KAREN, Harvard Medical School/Brigham and Women's Hospital, Boston, Massachusetts
- CLARK, SUSAN, Garvan Institute of Medical Research, Sydney, Australia
- COHEN, PAULA, Cornell University, Ithaca, New York
- COLAVITO, SIERRA, University of Wisconsin-La Crosse, La Crosse, Wisconsin
- COLLADO, MANUEL, Health Research Institute of Santiago Idis, Santiago de Compostela, Spain
- DA SILVA-ALVAREZ, SABELA, Health Research Institute of Santiago Idis, Santiago de Compostela, Spain
- DAHLHOFF, MAIK, Ludwig Maximilian University of Munich, Munich, Germany
- DANG, CHI VAN, University of Pennsylvania, Philadelphia, Pennsylvania
- DAS, KAKOLI, Duke-NUS Medical School, Singapore, Singapore
- DAS, SANJEEV, National Institute of Immunology, New Delhi, India
- DAVIS, NICHOLAS, Duke University, Durham, North Carolina

- DELFINO, TESS, Genentech, South San Francisco, California
 DEMARE, LAURA, Cold Spring Harbor Laboratory Press, Woodbury, New York
 DESWAL, SUMIT, Research Institute of Molecular Pathology, Vienna, Austria
 DETCHOKUL, SUJITRA, University of Melbourne, Heidelberg, Australia
 DEVOE, CRAIG, Northwell Health, Lake Success, New York
 DIERMEIER, SARA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 DONEN, MAURY, Manitoba Civil Service Superannuation Board, Winnipeg, Manitoba, Canada
 DORNIK, PIOTR, University of Texas MD Anderson Cancer Center, Houston, Texas
 DOW, LUKE, Weill Cornell Medicine, New York, New York
 DRAKE, JUSTIN, Rutgers Cancer Institute of New Jersey, New Brunswick, New Jersey
 DROSOS, YIANNIS, St. Jude Children's Research Hospital, Memphis, Tennessee
 DU, YI-CHIEH NANCY, Weill Cornell Medical College, New York, New York
 DUTTA, ADITYA, Columbia University Medical Center, New York, New York
 EBERLEIN, CATH, Cancer Research UK Manchester Institute, Manchester, United Kingdom
 EGEBLAD, MIKALA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 ELYADA, ELA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 ENGELMAN, JEFFREY, Massachusetts General Hospital, Boston, Massachusetts
 ENGLE, DANNIELLE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 ENOS, MIRIAM, Brigham and Women's Hospital, Boston, Massachusetts
 ER, EKREM EMRAH, Memorial Sloan Kettering Cancer Center, New York, New York
 EVAN, GERARD, University of Cambridge, Cambridge, United Kingdom
 EVANS, RONALD, Salk Institute for Biological Studies, La Jolla, California
 FEARON, DOUGLAS, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 FEIGIN, MICHAEL, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 FEIN, MIRIAM, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 FEIN LEVY, CAROLYN, Cohen Children's Medical Center, New Hyde Park, New York
 FEINBERG, ANDREW, Johns Hopkins University School of Medicine, Baltimore, Maryland
 FELDHAMN, NIKLAS, Imperial College London, London, United Kingdom
 FERNANDEZ, MARIO, H. Lee Moffitt Cancer Center, Tampa, Florida
 FILANT, JUSTYNA, University of Texas MD Anderson Cancer Center, Houston, Texas
 FILLMORE, CHRISTINE, Boston Children's Hospital, Boston, Massachusetts
 FIORANI, SIMONA, *Nature Communications*, London, United Kingdom
 FISHER, DANIEL, Centre National de la Recherche Scientifique, Montpellier, France
 FONSECA, CECILIA, University of São Paulo, São Paulo, Brazil
 FRAUMAN, ALBERT, University of Melbourne, Heidelberg, Australia
 FUJIWARA, HIROAKI, University of Tokyo, Tokyo, Japan
 GALLI, GIORGIO, Novartis Institute for Biomedical Research, Basel, Switzerland
 GANESAN, RAJKUMAR, Boehringer Ingelheim, Ridgefield, Connecticut
 GARTEL, ANDREI, University of Illinois College of Medicine, Chicago, Illinois
 GENOVESE, GIANNICOLA, University of Texas MD Anderson Cancer Center, Houston, Texas
 GHYSDAEL, JACQUES, Institute Curie, Orsay, France
 GIANNAKOU, ANDREAS, Pfizer Inc., Pearl River, New York
 GIMOTTY, PHYLLIS, University of Pennsylvania, Philadelphia, Pennsylvania
 GORRINI, CHIARA, Princess Margaret Hospital, Toronto, Ontario, Canada
 GOTTERER, JESSICA, Cold Spring Harbor Laboratory/Northwell Health, Cold Spring Harbor, New York
 GOURONNEC, ALIZÉE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 GRABOLE, NILS, F. Hoffmann-La Roche, Roche Innovation Center Basel, Basel, Switzerland
 GRAY, VERONICA, ORISE Postbac Fellow at FDA, Silver Spring, Maryland
 GRODZICKER, TERRI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 GUHA, UDAYAN, Center for Cancer Research/National Cancer Institute/National Institutes of Health, Bethesda, Maryland
 GUNES, CAGATAY, Ulm University, Ulm, Germany
 HABER, DANIEL, Massachusetts General Hospital, Charlestown, Massachusetts
 HAHN, WILLIAM, Dana-Farber Cancer Institute, Boston, Massachusetts
 HALL, MATTHEW, National Institutes of Health Center for Advancing Translational Sciences, Rockville, Maryland
 HAMMELL, AMY, Bristol-Myers Squibb, Princeton, New Jersey
 HAN, TENG, Weill Cornell Medicine, New York, New York
 HAN, XIAOQING, University of Miami, Miami, Florida
 HANDLY-SANTANA, ABRAM, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 HANEMANN, CLEMENS, Plymouth University, Plymouth, United Kingdom
 HAO, YUAN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 HART, TRAVER, University of Texas MD Anderson Cancer Center, Houston, Texas
 HASTINGS, KATHERINE, Yale University, New Haven, Connecticut
 HATZI, KATERINA, Memorial Sloan Kettering Cancer Institute, New York, New York
 HE, BING, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania
 HEBERT, JESS, Massachusetts Institute of Technology, Cambridge, Massachusetts
 HEDEGGER, KATHRIN, Ludwig Maximilian University at Munich, Munich, Germany
 HENDERSON, CHRISTINA, Moderna Therapeutics, Inc., Cambridge, Massachusetts
 HERR, WINSHIP, University of Lausanne, Lausanne, Switzerland
 HICKSON, IAN, The Panum Institute, Copenhagen, Denmark
 HO, YU-JUI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 HODGES, MARIA, Genome Medicine, London, United Kingdom
 HOESL, CHRISTINE, Ludwig Maximilian University at Munich, Munich, Germany
 HOGG, SIMON, Peter MacCallum Cancer Centre, Melbourne
 HOH, HONG HUAT, Okinawa Institute of Science and Technology, Onna, Okinawa, Japan
 HOPKINS, NANCY, Massachusetts Institute of Technology, Cambridge, Massachusetts
 HOULIHAN, SHAUNA, Sloan Kettering Institute, New York, New York
 HSU, HSIN-LING, National Health Research Institutes, Zhunan Town, Miaoli, Taiwan
 HU, BOMIAO, Yale University, New Haven, Connecticut
 HU, WENWEI, Rutgers University-Cancer Institute of New Jersey, New Brunswick, New Jersey
 HU, YUXUAN, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania
 HUANG, CHUN-HAO, Memorial Sloan Kettering Cancer Center, New York, New York
 HUANG, SIDONG, McGill University, Montreal, Quebec, Canada
 HUANG, XINYAN, University of New York, New York, New York
 HWANG, CHANG-IL, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 IGGO, RICHARD, University of Bordeaux, Bordeaux, France
 IYER, SWATHI, University of Kansas Medical Center, Kansas City, Kansas
 JACKS, TYLER, David H. Koch Institute for Integrative Cancer Research at MIT, Cambridge, Massachusetts
 JAHCHAN, NADINE, ORIC Pharmaceuticals, South San Francisco, California
 JAILKHANI, NOOR, Massachusetts Institute of Technology, Cambridge, Massachusetts
 JAIN, SAKET, University of Alberta, Alberta, Edmonton, Canada
 JAISWAL, ARUSHI, University of Toronto, Toronto, Ontario, Canada

SYMPOSIUM PARTICIPANTS

vii

- JAKIMO, ALAN, Hofstra University, Hempstead, New York
 JEN, JAYU, National Cheng Kung University, Tainan, Taiwan
 JIANG, YING, University of Virginia, Charlottesville, Virginia
 JIN, KE, University of Miami, Miami, Florida
 JOHNSON, RON, National Cancer Institute, Bethesda, Maryland
 JONKERS, JOS, Netherlands Cancer Institute, Amsterdam, The Netherlands
 JOSHI, NIKHIL, Massachusetts Institute of Technology, Cambridge, Massachusetts
 JUDE, JULIAN, Research Institute of Molecular Pathology (IMP), Vienna, Austria
 JUNE, CARL, University of Pennsylvania, Philadelphia, Pennsylvania
 KADOCH, CIGALL, Dana-Farber/Harvard Cancer Center, Boston, Massachusetts
 KAELIN, WILLIAM, Howard Hughes Medical Institute/Dana-Farber Cancer Institute, Boston, Massachusetts
 KALDIS, PHILIPP, Institute of Molecular and Cell Biology (IMCB), Singapore, Singapore
 KALLURI, RAGHU, University of Texas MD Anderson Cancer Center, Houston, Texas
 KANG, YIBIN, Princeton University, Princeton, New Jersey
 KARAKASHEVA, BAGRYANA, Sabanci University, Istanbul, Turkey
 KASTENHUBER, EDWARD, Memorial Sloan Kettering Cancer Center, New York, New York
 KATO, JUN-YA, Nara Institute of Science and Technology, Nara, Japan
 KATO, NORIKO, Nara Institute of Science and Technology, Nara, Japan
 KHAN, SHOWKHIN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 KIBERSTIS, PAULA, *Science Magazine*, Newbury, Massachusetts
 KIM, EEJUNG, Dana-Farber Cancer Institute, Cambridge, Massachusetts
 KIM, JAE-YOUNG, Moffitt Cancer Center, Tampa, Florida
 KIM, JIHUN, Asan Medical Center, Seoul, South Korea
 KIM, KYUNGTAEE, National Cancer Center, Goyang, South Korea
 KIM, YOUNG JIN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 KIM, YOUNGJOO, SUNY College at Old Westbury, Old Westbury, New York
 KOBAYASHI, AKIRA, Doshisha University, Kyotanabe, Japan
 KODIGEPALLI, MADHAV KARTHIK, The Ohio State University, Columbus, Ohio
 KOEGL, MANFRED, Boehringer Ingelheim RCV GmbH & Co KG, Vienna, Austria
 KOLLET, JUTTA, Miltenyi Biotec GmbH, Bergisch Gladbach, Germany
 KORIMERLA, NAVYATEJA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 KRUCHER, NANCY, Pace University, Pleasantville, New York
 KUNDU, SAMRAT, University of Texas MD Anderson Cancer Center, Houston, Texas
 KUZMIN, ELENA, McGill University, Goodman Cancer Centre, Montreal, Quebec, Canada
 KVAJO, MIRNA, *Cell*, Cambridge, Massachusetts
 LAI, SHAO-CHIANG (MICHAEL), Eastern Virginia Medical School, Norfolk, Virginia
 LAUGHNEY, ASHLEY, Memorial Sloan Kettering Cancer Center, New York, New York
 LAVI, SARA, Tel Aviv University, Tel Aviv, Israel
 LEBLEU, VALERIE, MD Anderson Cancer Center, Houston, Texas
 LEE, DA-HYE, Korea Advanced Institute of Science & Technology (KAIST), Daejeon, South Korea
 LEE, HO, National Cancer Center, Goyang-si, South Korea
 LEE, JAE, Kyungpook National University School of Medicine, Daegu, South Korea
 LEE, JE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 LEE, MATT, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 LEIBMAN, NICOLE
 LEIBOLD, JOSEF, Memorial Sloan Kettering Cancer Center, New York, New York
 LETAI, ANTHONY, Dana-Farber Cancer Institute, Boston, Massachusetts
 LI, AMY, Massachusetts Institute of Technology, Cambridge, Massachusetts
 LI, ANDREW, Dana-Farber Cancer Institute, Boston, Massachusetts
 LI, HUIPENG, Genome Institute of Singapore, Singapore, Singapore
 LI, RONG, University of Texas Health Science Center at San Antonio, San Antonio, Texas
 LI, WEI, Pennsylvania State University, Hershey College of Medicine, Hershey, Pennsylvania
 LI, XIANG, Memorial Sloan Kettering Cancer Center, New York, New York
 LI, YI, Baylor College of Medicine, Houston, Texas
 LIAO, SHENG-YOU, National Cheng Kung University, Tainan, Taiwan
 LIN, YI-JANG, Harvard University, Boston, Massachusetts
 LIOT, CAROLINE, New York University Medical Center, New York, New York
 LIU, HUI, Harvard Medical School/Beth Israel Deaconess Medical Center, Boston, Massachusetts
 LIU, JUAN, Rutgers Cancer Institute of New Jersey, New Brunswick, New Jersey
 LIU, YU, Sichuan University, Chengdu, China
 LIU, ZHIMIN, Stony Brook University, Stony Brook, New York
 LIVSHITS, GEULAH, Memorial Sloan Kettering Cancer Center, New York, New York
 LOCKWOOD, WILLIAM, British Columbia Cancer Research Centre, Vancouver, British Columbia, Canada
 LOIZOU, EVANGELIA, Memorial Sloan Kettering Cancer Center, New York, New York
 LOPES, EDUARDO, Universidade de São Paulo, São Paulo, Brazil
 LOVE, CASSANDRA, Duke University, Durham, North Carolina
 LOWE, SCOTT, Memorial Sloan Kettering Cancer Center, New York, New York
 LOZANO, GUILLERMINA (GIGI), University of Texas MD Anderson Cancer Center, Houston, Texas
 LU, RICHARD, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio
 LU, TSAILING, University Health Network (UHN), Toronto, Ontario, Canada
 LUGA, VALBONA, Weill Cornell Medicine, New York, New York
 LUJAMBIO, AMAIA, Icahn School of Medicine at Mount Sinai, New York, New York
 LUO, WEIBO, UT Southwestern Medical Center, Dallas, Texas
 LYDEN, DAVID, Weill Cornell Medical College of Cornell University, New York, New York
 LYONS, SCOTT, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 MAIA-SILVA, DIOGO, Faculdade de Medicina Universidade de Lisboa, Lisbon, Portugal
 MAIORINO, LAURA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 MAITY, TAPAN, National Institutes of Health, Bethesda, Maryland
 MAK, TAK, University of Toronto, Toronto, Ontario, Canada
 MAKI, ROBERT, Northwell Health, Lake Success, New York
 MANCHADO, EUSEBIO, Novartis, Basel, Switzerland
 MANSUKHANI, ALKA, New York University School of Medicine, New York, New York
 MARCH, NIKKI, Cancer Research UK Manchester Institute, Manchester, United Kingdom
 MARCHENKO, NATALIA, Stony Brook University, Stony Brook, New York
 MARDIS, ELAINE, Nationwide Children's Hospital Research Institute, Columbus, Ohio
 MAROTO, MIGUEL, Adaptimmune, Abingdon, United Kingdom
 MARTINEZ, LUIS, Stony Brook University, Stony Brook, New York
 MASCARENO, MANYA, State University of New York, College at Old Westbury, Old Westbury, New York
 MATHEW, GRINU, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 MAURER, CARLO, Columbia University, New York, New York
 MAYER, ANDREAS, Harvard Medical School, Boston, Massachusetts
 MAYLE, ALLISON, Memorial Sloan Kettering Cancer Center, New York, New York
 MCKENNA, ELIZABETH, *Cancer Discovery*, Philadelphia, Pennsylvania
 MCKINNEY, KRISTINE, Moderna Therapeutics, Cambridge, Massachusetts
 MCMAHON, MARTIN, University of Utah, Huntsman Cancer Institute, Salt Lake City, Utah
 MELNICK, ARI, Weill Cornell Medical College, New York, New York
 MENSSEN, ANTJE, Ludwig Maximilian University at Munich, Munich, Germany

- MERTENS, CLAUDIA, The Rockefeller University, New York, New York
 MIETHING, CORNELIUS, Universitätsklinikum Freiburg, Freiburg, Germany
 MIIKKULAINEN, PETRA, University of Turku, Turku, Finland
 MILLS, ALEA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 MIN, JIMIN, Seoul National University, Seoul, South Korea
 MOCK, BEVERLY, National Cancer Institute, National Institutes of Health, Bethesda, Maryland
 MOLIK, DAVID, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 MOLINA, JENNIFER, MD Anderson Cancer Center, Houston, Texas
 MOLL, UTE, Stony Brook University, Stony Brook, New York
 MONSERRAT-SANCHEZ, JOSEP, The Francis Crick Institute, London, United Kingdom
 MOON, HYEONG-GON, Seoul National University College of Medicine, Seoul, South Korea
 MORRIS IV, JOHN, Memorial Sloan Kettering Cancer Center, New York, New York
 MORRISON, SEAN, UT Southwestern Medical Center, Dallas, Texas
 MOU, HAIWEI, University of Massachusetts Medical School, Worcester, Massachusetts
 MU, DAVID, Eastern Virginia Medical School, Norfolk, Virginia
 MUHAR, MATTHIAS, Research Institute for Molecular Pathology, Wien, Austria
 MULEY, ASHLESHA, Weill Cornell Medicine, New York, New York
 MURANEN, TARU, Beth Israel Deaconess Medical Center, Boston, Massachusetts
 MUZUMDAR, MANDAR, Koch Institute at Massachusetts Institute of Technology, Cambridge, Massachusetts
 NACIRI, IKRAME, University Paris Diderot/CNRS, Paris, France
 NAKANISHI, SHIMA, H. Lee Moffitt Cancer Center, Tampa, Florida
 NAKATSUKA, TAKUMA, The University of Tokyo, Bunkyo-ku, Tokyo, Japan
 NAZ, SARWAT, National Cancer Institute, National Institutes of Health, Bethesda, Maryland
 NEDOSPASOV, SERGEI, Engelhardt Institute of Molecular Biology, Moscow, Russia
 NEEL, BENJAMIN, New York University School of Medicine, New York, New York
 NELSON, SARAH, University of Colorado Denver, Aurora, Colorado
 NEMAJEROVA, ALICE, Stony Brook University, Stony Brook, New York
 NG, SHENG RONG, Koch Institute at Massachusetts Institute of Technology, Cambridge, Massachusetts
 NGO, BRYAN, Weill Cornell Medical College, New York City, New York
 NOLAN, EMMA, Walter and Eliza Hall Institute, Melbourne, Australia
 NOWAK, DAWID, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 OLIVE, KENNETH, Columbia University, New York, New York
 OLSEN, SARAH NAOMI, Brigham and Women's Hospital, Boston, Massachusetts
 ONI, TOBILOBA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 O'ROURKE, KEVIN, Memorial Sloan Kettering Cancer Center, New York, New York
 OSER, MATTHEW, Dana-Farber Cancer Institute, Boston, Massachusetts
 OUDIN, MADELEINE, Massachusetts Institute of Technology, Cambridge, Massachusetts
 OZDUMAN, KORAY, Acibadem University, School of Medicine, Istanbul, Turkey
 PADDOCK, MARCIA, Weill Cornell Medicine/New York-Presbyterian, New York, New York
 PAL, DEBJANI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 PAPAGIANNAKOPOULOS, THALES, New York University Medical School, New York, New York
 PARADA, LUIS, Memorial Sloan Kettering Cancer Center, New York, New York
 PARDEE, TIMOTHY, Wake Forest University School of Medicine, Winston-Salem, North Carolina
 PARK, WOO-YONG, Korea Advanced Institute of Science and Technology, Daejeon, South Korea
 PARK, YOUNGKYU, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 PARRILLA-MONGE, LAURA, Stony Brook University, Stony Brook, New York
 PASHINE, ACHAL, Bristol-Myers Squibb, Lawrenceville, New Jersey
 PAUL, DORU, Northwell Health, Lake Success, New York
 PENG, DAVID, MD Anderson Cancer Center, Houston, Texas
 PHELPS, CODY, Eastern Virginia Medical School, Norfolk, Virginia
 PISKOL, ROBERT, Genentech, South San Francisco, California
 PISKOUNOVA, ELENA, UT Southwestern, Dallas, Texas
 PISTERZI, PAOLA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 POLITI, KATERINA, Yale University, New Haven, Connecticut
 POLLOCK, MILA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 POLYAK, KORNELIA, Dana-Farber Cancer Institute, Boston, Massachusetts
 POLYANSKAYA, SOFYA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 POMMIER, ARNAUD, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 POWERS, SCOTT, Cold Spring Harbor Laboratory, Woodbury, New York
 PREMSRIRUT, PREM, Mirimus, Inc., Woodbury, New York
 PRUMMER, MICHAEL, ETH Zürich, Zürich, Switzerland
 PULVIRENTI, TEODORO, *Nature Cell Biology*, New York, New York
 QIAO, SHUXI, Mass General Hospital and Harvard Medical School, Boston, Massachusetts
 RAGOUSIS, IOANNIS, McGill University, Montreal, Quebec, Canada
 RAJU, PRAVEEN, Weill Cornell Medical College, New York, New York
 RAMSEY, MATTHEW, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts
 RANJAN, ATUL, University of Kansas Medical Center, Kansas City, Kansas
 RANTANEN, KRISTA, University of Turku, Turku, Finland
 RAO, ANGAD, National University of Singapore, Singapore, Singapore
 RAO, MANISHA, Stony Brook University, Stony Brook, New York
 RAPTI, GEORGE, Northwell Health, Lake Success, New York
 RAVICHANDRAN, PRIYADARSHINI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 REMPEL, RACHEL, Duke University Medical Center, Durham, North Carolina
 RENNACK, JONATHAN, Michigan State University, East Lansing, Michigan
 RITHO, JOAN, MD Anderson Cancer Center, Houston, Texas
 ROE, JAE SEOK, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 ROITMAN, LIOR, Weizmann Institute, Rehovot, Israel
 ROMESSER, PAUL, Memorial Sloan Kettering Cancer Center, New York, New York
 ROSE, JOHNATHON, MD Anderson Cancer Center, Houston, Texas
 ROSEN, MONICA, Weill Cornell Medicine, New York, New York
 ROSEN, NEAL, Memorial Sloan Kettering Cancer Center, New York, New York
 ROUNBEHLER, ROBERT, H. Lee Moffitt Cancer Center, Tampa, Florida
 RUSCETTI, MARCUS, Memorial Sloan Kettering Cancer Center, New York, New York
 RYAN, MOLLY, Yale University, New Haven, Connecticut
 SACCHI, NICOLETTA, Roswell Park Cancer Institute, Buffalo, New York
 SACHAN, NALANI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 SADEK, JOULIANA, Weill Cornell Medicine, New York, New York
 SADELAIN, MICHEL, Memorial Sloan Kettering Cancer Center, New York, New York
 SAFFRAN, DOUG, Warp Drive Bio, Inc., Cambridge, Massachusetts
 SAID, SUZANNE, Agensys Inc., Santa Monica, California
 SALAMI, FARIMAH, St. Jude Children's Research Hospital, Memphis, Tennessee
 SALOTTI, JACQUELINE, National Cancer Institute, National Institutes of Health, Frederick, Maryland
 SANCHEZ-RIVERA, FRANCISCO, Memorial Sloan Kettering Cancer Center, New York, New York
 SAROSIEK, KRISTOPHER, Dana-Farber Cancer Institute, Boston, Massachusetts
 SASAKI, TOMOAKI, Yale University, New Haven, Connecticut

SYMPOSIUM PARTICIPANTS

ix

- SAWYERS, CHARLES, Memorial Sloan Kettering Cancer Center, New York, New York
- SCAGLIONI, PIER, UT Southwestern Medical Center, Dallas, Texas
- SCARBOROUGH, HANNAH, University of Colorado Denver, Denver, Colorado
- SCHMIDT, LEAH, Koch Institute at Massachusetts Institute of Technology, Cambridge, Massachusetts
- SCHOENFELD, ALAN, Adelphi University, Garden City, New York
- SCOTT, ANDREW, North Dakota State University, Fargo, North Dakota
- SEMEANOVA, EKATERINA, The Netherlands Cancer Institute (NKI), Amsterdam, The Netherlands
- SERRANO, MANUEL, Spanish National Cancer Center (CNIO), Madrid, Spain
- SEVER, RICHARD, Cold Spring Harbor Laboratory Press, Woodbury, New York
- SHAND, TIFFANY, University of Virginia, Charlottesville, Virginia
- SHAW, REUBEN, Salk Institute for Biological Studies, La Jolla, California
- SHELTZER, JASON, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SHEN, ROGER, Academia Sinica, Taipei, Taiwan
- SHI, JUNWEI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SHI, QING, Baylor College of Medicine, Houston, Texas
- SHIELDS, MARIO, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SHIROLE, NITIN, Cold Spring Harbor Laboratory, Cold Spring Harbor, Alabama
- SHU, SHAOKUN, Dana-Farber Cancer Institute, Boston, Massachusetts
- SIERRA GONZALEZ, PABLO, Beatson Institute for Cancer Research, Glasgow, United Kingdom
- SIMON, M. CELESTE, University of Pennsylvania Medical School, Philadelphia, Pennsylvania
- SIMÓN CARRASCO, LUCÍA, Spanish National Cancer Research Center, Madrid, Spain
- SINDHWANI, SHREY, University of Toronto, Toronto, Ontario, Canada
- SINGH, KAMINI, Memorial Sloan Kettering Cancer Center, New York, New York
- SINGH, MALLIKA, ORIC Pharmaceuticals, South San Francisco, California
- SMITH, MATTHEW, H. Lee Moffitt Cancer Center, Tampa, Florida
- SOLIT, DAVID, Memorial Sloan Kettering Cancer Center, New York, New York
- SOLOMON, LARRY, AbbVie, Inc, North Chicago, Illinois
- SONG, DONGYAN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SONG, JI-YING, The Netherlands Cancer Institute (NKI), Amsterdam, The Netherlands
- SORDELLA, RAFFAELLA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SPECTOR, DAVID, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- SRIDEVI, PRIYA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- STAHLHUT, CARLOS, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- STEINBERG, BETTIE, The Feinstein Institute, Northwell Health, Manhasset, New York
- STEWART, DAVID, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- STILLMAN, BRUCE, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- STOMMEL, JAYNE, National Cancer Institute, Bethesda, Maryland
- STRASSER, SAMANTHA DALE, Massachusetts Institute of Technology, Cambridge, Massachusetts
- STRATTON, MICHAEL, The Wellcome Trust Sanger Institute, Hinxton, Cambridge, United Kingdom
- STROHECKER, ANNE, The Ohio State University, Columbus, Ohio
- SÜLTSMANN, HOLGER, German Cancer Research Center/National Center for Tumor Diseases, Heidelberg, Germany
- SUNDARESAN, VARSHA, University of Florida, Gainesville, Florida
- SUSSMAN, HILLARY, Cold Spring Harbor Laboratory Press, Woodbury, New York
- SYMONS, MARC, Feinstein Institute, Manhasset, New York
- TALOS, FLAMINIA, Stony Brook University, Stony Brook, New York
- TAMMELA, TUOMAS, Massachusetts Institute of Technology, Cambridge, Massachusetts
- TAN, KAI, University of Pennsylvania, Philadelphia, Pennsylvania
- TANAKA, YASUO, The University of Tokyo, Tokyo, Japan
- TANG, HAIDONG, UT Southwestern Medical Center, Dallas, Texas
- TANG, XUMING, The University of Hong Kong, Hong Kong, Hong Kong
- TATEISHI, KEISUKE, The University of Tokyo, Tokyo, Japan
- TEESALU, TAMBET, University of Tartu, Tartu, Estonia
- TELERMAN, ADAM, Institut Gustave Roussy, Villejuif, France
- THOMPSON, CRAIG, Memorial Sloan Kettering Cancer Center, New York, New York
- THOMSON, TIMOTHY, CSIC, Barcelona, Spain
- TOMASZEWSKI, MONICA, Thermofisher, Pittsburgh, Pennsylvania
- TONELLI, CLAUDIA, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- TRAN, NGOC, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- TRAN QUANG, CHRISTINE, Institut Curie, Orsay, France
- TROTSMAN, LLOYD, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- TRUINI, ANNA, Yale University, New Haven, Connecticut
- TRUITT, MORGAN, The Salk Institute for Biological Studies, La Jolla, California
- TUVESON, DAVID, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- TZENG, HONG-TAI, National Cheng Kung University, Tainan City, Taiwan
- UNNI, ARUN, Weill Cornell Medicine, New York, New York
- VAKILI, JALAL, Servier Laboratories, Suresnes Cedex, France
- VAKOC, CHRISTOPHER, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- VANNER, ROBERT, Princess Margaret Cancer Centre, Toronto, Ontario, Canada
- VARMUS, HAROLD, Weill Cornell Medical College, New York, New York
- VENUGOPALAN, ABHILASH, National Cancer Institute, Bethesda, Maryland
- VERZI, MICHAEL, Rutgers, The State University of New Jersey, Piscataway, New Jersey
- VIJAY, VINDHYA, University of Florida, Gainesville, Florida
- VOUSDEN, KAREN, Cancer Research UK Beatson Institute, Glasgow, United Kingdom
- WAGENBLAST, ELVIN, University Health Network (UHN), Toronto, Ontario, Canada
- WANG, HONG, St. Jude Children's Research Hospital, Memphis, Tennessee
- WANG, JIN, Stony Brook University, South Setauket, New York
- WANG, JINHUA, New York University Medical School, New York, New York
- WANG, LU-HAI, National Health Research Institutes, Miaoli County, Taiwan
- WANG, WEN-CHI, National Yang-Ming University, Taipei, Taiwan
- WANG, YA TING, Academia Sinica, Taipei, Taiwan
- WANG, YANG, Sichuan University, Chengdu, China
- WATRUD, KAITLIN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- WEAVER, VALERIE, University of California, San Francisco, San Francisco, California
- WEINBERG, ROBERT, Whitehead Institute for Biomedical Research, Cambridge, Massachusetts
- WEISBROD, STU, Iguana Healthcare Partners, LLC, New York, New York
- WEISS, JOSH, Weill Cornell, New York, New York
- WEISSMAN, IRVING, Stanford University, Stanford, California
- WESTCOTT, PETER, Massachusetts Institute of Technology, Cambridge, Massachusetts
- WHITE, EILEEN, The Rutgers Cancer Institute of New Jersey, New Brunswick, New Jersey
- WIGLER, MICHAEL, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
- WILKINSON, JOHN, North Dakota State University, Fargo, North Dakota
- WILKINSON, JOHN, University of Michigan, Ann Arbor, Michigan
- WITKOWSKI, JAN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York

SYMPOSIUM PARTICIPANTS

WU, GANG, CAS-MPG Partner Institute for Computational Biology, Shanghai, China
 WU, MATTHEW, Stony Brook University, Stony Brook, New York
 XU, DAZHONG, New York Medical College, Valhalla, New York
 XU, LONGYONG, Baylor College of Medicine, Houston, Texas
 XUE, WEN, University of Massachusetts Medical School, Cambridge, Massachusetts
 YAN, CHUNHUA, National Cancer Institute, Rockville, Maryland
 YAN, YAN, Research Program Units, Helsinki, Finland
 YANG, DIAN, Stanford University, Stanford, California
 YANG, GUANG, Jounce Therapeutics, Cambridge, Massachusetts
 YANG, LI, National Cancer Institute, National Institutes of Health, Bethesda, Maryland
 YANG, T. JONATHAN, Memorial Sloan Kettering Cancer Center, New York, New York
 YAO, MAOJIN, University of Virginia, Charlottesville, Virginia
 YAO, MIN, University of Kansas Medical Center, Kansas City, Kansas
 YE, XIN, Whitehead Institute for Biomedical Research, Cambridge, Massachusetts
 YEH, EDWARD, MD Anderson Cancer Center, Houston, Texas
 YEO, SYN, University of Cincinnati, Cincinnati, Ohio

YORDANOV, GEORGI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 YU, ALLEN, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 YU, XIAOFEI, The Rockefeller University, New York, New York
 YUEN, KOBE, Stowers Institute for Medical Research, Kansas City, Missouri
 ZENDER, LARS, University of Tübingen, Tübingen, Germany
 ZHANG, HONGBING, Chinese Academy of Medical Sciences, Beijing, China
 ZHANG, HONGXIANG, Third Rock Ventures, Boston, Massachusetts
 ZHANG, PING, University of Oxford, Oxford, United Kingdom
 ZHANG, SIWEI, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York
 ZHANG, XU, Zhejiang University, Hangzhou, China
 ZHAO, NA, Baylor College of Medicine, Houston, Texas
 ZHAO, SHAYING, University of Georgia, Athens, Georgia
 ZHAO, XIAOYU, Stony Brook University, Stony Brook, New York
 ZHAO, ZHEN, Memorial Sloan Kettering Cancer Center, New York, New York
 ZHENG, YUXIANG, Weill Cornell Medical College, New York, New York

Row 1: P. Raju, J. Weiss; J. Sheltzer, C. Gunes; S. Nedospasov, L. Pollock

Row 2: H. Varmus, J. Witkowski; W. Herr, S. Weisbrod

Row 3: G. Burgos-Barragan, S. Said, J. Sadek; R. Alvania; V. Sundaresan, V. Vijay

Row 4: U. Pedmale, D. Stewart, D. Spector, M. Spector, P. Sherwood

Row 1: P. Westcott, M. Truitt; M. Koegl, D. Fisher; D. Tuveson, C. Caldas
 Row 2: B. Steinberg, M. Symons; J. Jonkers, L. Zender; G. Evan, M. McMahon
 Row 3: P. Kaldas, E. White; M. Muhar, B. Bosbach; A. Menssen, M. Koegl
 Row 4: R. Evans; C. Caldas, M. Stratton; B. Neel, C. June
 Row 5: J. Witkowski, W. Kaelin; D. Lyden, B. Neel; J. Brugge, R. Sever

Row 1: P. Scaglioni, G. Genovese; S. Lowe; M. Kvajo, S. Morrison
Row 2: D. Saffran, C. Fonseca; S. Challa, S. Nelson
Row 3: J. Kollet, R. Johnson; K. Vousden, G. Lozano; P. Raju, L. Beverly
Row 4: Lowe Lab

Row 1: L. Parada; C. Thompson; V. Weaver

Row 2: A.M. Laughney, N. Grabole; C. Vakoc, P. Kiberstis

Row 3: C. Sawyers, S. Armstrong; Y. Tanaka; M. Stratton, R. Weinberg

Row 4: R. Alvania, M. Kvajo; H. Varmus, S. Nedospasov, I. Weissman; C. Hanemann, E. Benevolonskaya

Row 1: P. Miikkulainen, K. Rantanen, A. Menssen; L. Maiorino, E. Bruzas
 Row 2: M.C. Simon, C.V. Dang; E. Kuzmin, T. Hunt; T. Papagiannakopoulos, K. Politi
 Row 3: S. Clark, M. Kvajo; U. Moll, G. Lozano, R. Iggo
 Row 4: N. Kato, J.-y. Kato; P. Kaldis, L. Simón Carrasco, C. Fearon; A. Letai

Foreword

Cancer is a deadly disease that will afflict one out of every two to three people in the developed world in their lifetime. Recent years have produced transformative discoveries revealing the mechanisms behind the development and progression of cancer and the implementation of targeted cancer therapies in the clinic based on these discoveries. We have defined the mutational landscape of many cancers and with that the incipient driver mutations. Sophisticated and elegant models now exist for many types of cancer, and we understand in great detail the changes in signaling and gene expression that promote cancer and have begun to unravel the antitumor immune response. Cell death and survival mechanisms used by cancer cells have been identified and therapeutically exploited, and we have revealed processes that dictate cancer cell growth, repair, and proliferation and have the means to inhibit these processes. We have also seen advances in the mechanistic understanding, implementation, and deployment of cytotoxic cancer therapy. Collectively these advances are improving both the quality of life and overall survival of cancer patients.

The decision to focus the 81st Cold Spring Harbor Laboratory Symposium on Targeting Cancer reflected the enormous research progress achieved in recent years and provided a broad synthesis of the current state of the field, setting the stage for future discoveries and applications. Implications of how the underlying science can drive improvements in diagnostic, prognostic, and therapeutic approaches were a major theme throughout the Symposium. Previous Symposia that have included significant aspects of cancer research have occurred on a roughly five- to 10-year cycle, notably but not limited to Genes and Mutations (1951); Cellular Regulatory Mechanisms (1961); Transcription of Genetic Material (1970); Tumor Viruses (1974); Viral Oncogenes (1979); The Cell Cycle (1991); The Molecular Genetics of Cancer (1994); Biological Responses to DNA Damage (2000); and Molecular Approaches to Controlling Cancer (2005).

Major themes and topics highlighted at the 2016 Symposium included Cancer Genes and Genomes (genome stability, chromatin, epigenetic regulation); Cancer Pathways (signaling pathways, networks); Tumor Cell Biology (cells of origin, metabolism, autophagy, senescence); Cancer Growth & Progression (microenvironment, stroma/niche, tumor evolution, metastasis); Innate & Adaptive Immune Responses (inflammation, immunotherapies); and Enabling Technologies (single-cell sequencing, imaging, genetic screens, genome editing, organoids). Opening night speakers included Elaine Mardis (Nationwide Children's Hospital Research Institute) on translating cancer genomics into therapeutic target identification and vaccine design, Craig Thompson (Memorial Sloan Kettering Cancer Center), who spoke on the emerging treatment paradigm exploiting cancer metabolism, Carl June (University of Pennsylvania) on the use of genetic editing to generate synthetic lethal T cells, and Tyler Jacks (David H. Koch Institute for Integrative Cancer Research at MIT), who addressed engineering the cancer genome. Charles Sawyers (HHMI/Memorial Sloan Kettering Cancer Center) delivered an outstanding Dorcas Cummings Lecture on "Reflections on Precision Medicine and Cancer Moonshots" for Laboratory friends, neighbors, and Symposium participants prior to the annual Symposium dinners. Joan Brugge (Harvard Medical School) provided a masterful Summary at the conclusion of the Symposium immediately prior to the final banquet.

This Symposium was attended by almost 490 scientists from universities around the country and internationally, and the program included 55 invited presentations and more than 200 poster presentations. To disseminate the latest results and discussion of the Symposium to a wider audience, attendees were able to share many of the Symposium talks with their colleagues who were unable to attend using the Leading Strand video archive. A collection of interviews by Gemma Alderton (*Nature Reviews Cancer*), Paula Kiberstis (*Science*), Mirna Kvafo (Cell Press), Elizabeth McKenna (*Cancer Discovery/AACR*), Richard Sever (CSHL Press), and Jan Witkowski (CSHL Banbury Center) with leading experts in the field were arranged during the Symposium and distributed as free video from the Cold Spring Harbor Symposium interviews website.

We thank Val Pakaluk, Mary Smith, Ed Campodonico, and his staff in the Meetings & Courses Program for their assistance in organizing and running the Symposium, and John Inglis and his staff at Cold Spring Harbor Laboratory Press, particularly Inez Sialiano, Jan Argentine, Kathleen Bubbeo, and Denise Weiss. Major support was provided by the CSHL-Northwell Health Partnership, with additional

support provided by Genomic Health and Fluidigm. Financial support from the corporate sponsors of our meetings program is essential for these Symposia to remain a success, and we are most grateful for their support.

Symposium Organizers

Scott Lowe, Memorial Sloan Kettering Cancer Center
Kornelia Polyak, Dana-Farber Cancer Institute
David Stewart, Cold Spring Harbor Laboratory
Bruce Stillman, Cold Spring Harbor Laboratory
Eileen White, The Rutgers Cancer Institute of New Jersey

Editors

David Stewart, Cold Spring Harbor Laboratory
Bruce Stillman, Cold Spring Harbor Laboratory

Sponsors

Contributions from the following companies provide core support for the Cold Spring Harbor meetings program.

Corporate Benefactor

Regeneron

Corporate Sponsors

Agilent Technologies
Bristol-Myers Squibb Company
Calico Labs
Genentech, Inc.
Life Technologies (part of Thermo Fisher Scientific)
Merck
Monsanto Company
New England Biolabs
Pfizer

Corporate Affiliate

Ionis Pharmaceuticals

Contents

Symposium Participants	v
Foreword	xvii
 Cancer Stem Cells	
Normal and Neoplastic Stem Cells <i>Melissa N. McCracken, Benson M. George, Kevin S. Kao, Kristopher D. Marjon, Tal Raveh, and Irving L. Weissman</i>	1
Targeting the Epithelial-to-Mesenchymal Transition: The Case for Differentiation-Based Therapy <i>Diwakar R. Pattabiraman and Robert A. Weinberg</i>	11
Trimming the Vascular Tree in Tumors: Metabolic and Immune Adaptations <i>Elizabeth Allen, Rindert Missiaen, and Gabriele Bergers</i>	21
Cell of Origin and Cancer Stem Cells in Tumor Suppressor Mouse Models of Glioblastoma <i>Sheila R. Alcantara Llaguno, Xuanhua Xie, and Luis F. Parada</i>	31
 Genetics and Epigenetics	
The Enigma of p53 <i>Guillermo Lozano</i>	37
Alterations in Three-Dimensional Organization of the Cancer Genome and Epigenome <i>Joanna Achinger-Kawecka, Philippa C. Taberlay, and Susan J. Clark</i>	41
Composition and Function of Mammalian SWI/SNF Chromatin Remodeling Complexes in Human Disease <i>John L. Pulice and Cigall Kadoch</i>	53
The Essential Transcriptional Function of BRD4 in Acute Myeloid Leukemia <i>Jae-Seok Roe and Christopher R. Vakoc</i>	61
 Metabolism	
Reexamining How Cancer Cells Exploit the Body's Metabolic Resources <i>Craig B. Thompson and Wilhelm Palm</i>	67
Autophagy, Metabolism, and Cancer <i>Jessie Yanxiang Guo and Eileen White</i>	73
A Time for MYC: Metabolism and Therapy <i>Chi V. Dang</i>	79
Beyond the Oncogene Revolution: Four New Ways to Combat Cancer <i>Thorsten Berger, Mary E. Saunders, and Tak W. Mak</i>	85
Lipid Synthesis Is a Metabolic Liability of Non–Small Cell Lung Cancer <i>Robert U. Svensson and Reuben J. Shaw</i>	93
 Targets, Vaccines, and Therapeutics	
Cancer Immunogenomics: Computational Neoantigen Identification and Vaccine Design <i>Jasreet Hundal, Christopher A. Miller, Malachi Griffith, Obi L. Griffith, Jason Walker, Susanna Kiwala, Aaron Graubert, Joshua McMichael, Adam Coffman, and Elaine R. Mardis</i>	105
Targeting HIF2 in Clear Cell Renal Cell Carcinoma <i>Hyejin Cho and William G. Kaelin</i>	113
BET Bromodomain Proteins as Cancer Therapeutic Targets <i>Shaokun Shu and Kornelia Polyak</i>	123
To Prime, or Not to Prime: That Is the Question <i>Danielle S. Potter and Anthony Letai</i>	131
Genetic Dissection of Cancer Development, Therapy Response, and Resistance in Mouse Models of Breast Cancer <i>Stefano Annunziato, Marco Barazas, Sven Rottenberg, and Jos Jonkers</i>	141
 Microenvironment and Metastasis	
Tumor–Stroma Interactions in Bone Metastasis: Molecular Mechanisms and Therapeutic Implications <i>Hanqiu Zheng, Wenyang Li, and Yibin Kang</i>	151

Cancer, Oxidative Stress, and Metastasis	<i>Jennifer G. Gill, Elena Piskounova, and Sean J. Morrison</i>	163
RON Signaling Is a Key Mediator of Tumor Progression in Many Human Cancers	<i>Najme Faham and Alana L. Welm</i>	177
Physical and Chemical Gradients in the Tumor Microenvironment Regulate Tumor Cell Invasion, Migration, and Metastasis	<i>Madeleine J. Oudin and Valerie M. Weaver</i>	189
Models of Cancer		
Pathways Involved in Formation of Mammary Organoid Architecture Have Keys to Understanding Drug Resistance and to Discovery of Druggable Targets	<i>Saori Furuta and Mina J. Bissell</i>	207
Explaining the Paucity of Intratumoral T Cells: A Construction Out of Known Entities	<i>Douglas T. Fearon</i>	219
Modeling Breast Cancer Intertumor and Intratumour Heterogeneity Using Xenografts	<i>Alejandra Bruna, Oscar M. Rueda, and Carlos Caldas</i>	227
Challenges and Opportunities in Modeling Pancreatic Cancer	<i>Michael E. Feigin and David A. Tuveson</i>	231
Cancer Genomics and Tumor Heterogeneity		
Functional Genomic Characterization of Cancer Genomes	<i>Thomas P. Howard, Francisca Vazquez, Aviad Tsherniak, Andrew L. Hong, Mik Rinne, Andrew J. Aguirre, Jesse S. Boehm, and William C. Hahn</i>	237
How Cancer Genomics Drives Cancer Biology: Does Synthetic Lethality Explain Mutually Exclusive Oncogenic Mutations?	<i>Harold Varmus, Arun M. Unni, and William W. Lockwood</i>	247
A Pipeline for Drug Target Identification and Validation	<i>Eusebio Manchado, Chun-Hao Huang, Nilgun Tasdemir, Darjus F. Tschaharganeh, John E. Wilkinson, and Scott W. Lowe</i>	257
Single-Cell Analysis of Circulating Tumor Cells as a Window into Tumor Heterogeneity	<i>David T. Miyamoto, David T. Ting, Mehmet Toner, Shyamala Maheswaran, and Daniel A. Haber</i>	269
Discovery of Double-Stranded Genomic DNA in Circulating Exosomes	<i>Raghu Kalluri and Valerie S. LeBleu</i>	275
Summary		
Moving Closer to Victory	<i>Taru Muranen and Joan S. Brugge</i>	281
Dorcas Cummings Lecture		
Charles Sawyers		291
Conversations at the Symposium		
Gabriele Bergers		299
Joan Brugge		301
Karen Cichowski		304
Susan Clark		306
Gerard Evan		309
Daniel Haber		311
William Kaelin		314
Raghu Kalluri		317
Scott Lowe		320
Guillermina (Gigi) Lozano		323
David Lyden		326
Elaine Mardis		328
Sean Morrison		331
Benjamin Neel		334

CONTENTS

xxi

Luis Parada	336
Sir Michael Stratton	338
David Tuveson	341
Christopher Vakoc	344
Harold Varmus	347
Karen Vousden	351
Valerie Weaver	354
Robert Weinberg	357
Eileen White	360
Author Index	363
Subject Index	365

Cold Spring Harbor Symposia on Quantitative Biology

Front Matter

Cold Spring Harb Symp Quant Biol 2016 81: i-xxi
Access the most recent version at doi:[10.1101/sqb.2016.81.FM](https://doi.org/10.1101/sqb.2016.81.FM)

License

Email Alerting Service

Receive free email alerts when new articles cite this article - sign up in the box at the top right corner of the article or [click here](#).

To subscribe to *Cold Spring Harbor Symposia on Quantitative Biology* go to:
<http://symposium.cshlp.org/subscriptions>