Biocommunication of Archaea

Guenther Witzany
Editor

Biocommunication of Archaea

Springer

Editor
Guenther Witzany
Telos-Philosophische Praxis
Bürmoos, Salzburg
Austria

ISBN 978-3-319-65535-2 ISBN 978-3-319-65536-9 (eBook)
DOI 10.1007/978-3-319-65536-9

Library of Congress Control Number: 2017949167

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

Biocommunication of Archaea is the last book in this exceptional new series on communication as prerequisite for all biotic coordination processes that apply biocommunication theory to all organismic kingdoms or domains of life, respectively.

In the first book "Biocommunication and Natural Genome Editing" (2010), the whole theoretical concept was outlined, followed by "Biocommunication in Soil Microorganisms" (2011), "Biocommunication of Plants" (2012 with co-editor Frantisek Baluska), "Biocommunication of Fungi," and "Viruses: Essential Agents of Life." In 2014, "Biocommunication of Animals" followed and in 2016 also the investigation on a species of unicellular eukaryotes "Biocommunication of Ciliates" (2016, together with co-editor Mariusz Nowacki).

Theory of biocommunication is the first and only theory that integrates all domains of life empiristically in a non-reductionistic and non-mechanistic way. This theory of biocommunication strictly avoids metaphysical narratives (e.g., holism, mechanism, physicalism) and opens a groundbreaking understanding of life.

The biocommunicative approach investigates both communication processes within and among cells, tissues, organs and organisms as sign-mediated interactions, and nucleotide sequences as code, i.e., language-like text, which follows in parallel three (3) kinds of rules: combinatorial (syntactic), context-sensitive (pragmatic), and content-specific (semantic).

Key levels of biocommunication research therefore integrate (1) sensing, memory, and interpretation of abiotic indices, (2) intraorganismic communication (intra- and intercellular), (3) interorganismic communication, and (4) transorganismic communication.

Biocommunication theory translates empirical data into a coherent perspective on the functions within and between biological organisms and arguably leads to a sustainable integrative biology.

Bürmoos, Austria — Guenther Witzany

Preface

Communication means interactions that are mediated by signals in contrast to purely physicochemical interactions where no signals are present. Additionally these sign-mediated interactions need rules on how the signals may be combined to transport more complex informational content. Last but not least, communicative interactions mediated by signs depend essentially on living agents that are able to follow such rules of sign use. Additionally it must be mentioned that sign-mediated rule-governed interactions represent a kind of social interaction, i.e., communication processes are social events, involving groups of interacting agents that share the rules on how to use signals, and this means that group identity is essential in living nature.

Whenever living cells, whether akaryotic or eukaryotic, coordinate their behavior, communication processes are necessary to reach coordinative goals. Each activity on all levels of biocommunication (intraorganismic, interorganismic, transorganismic, and generating response behavior to abiotic influences) is usually achieved by means of specialized signaling. If these signaling processes are disturbed, damaged or incomplete, the activity remains incomplete or rudimentary or is deleted.

The prerequisites of communication are its social character, its dependence on the use of signals according to three levels of rules, the primacy of context (pragmatics) which determines the meaning/function (semantics) of the used signs and—last but not least—the inherent capability of sign-using agents to change these rules of sign use according to environmental or adaptational needs. None of which is found in inanimate nature. No signs, no semiotic rules, and no socially interacting living agents are present when, e.g., water freezes to ice.

The change of sign-using rules, which gives signals and sign sequences new meanings that never existed before and are not the result of a recombination of former ones, is an inherent feature of living agents competent to use a natural language or a natural code. The generation of new sign sequences is essentially not the result of the selection of beneficial mutations out of an abundance of defective variants. In contrast to this passive derivation narrative of positive selective forces,

the generation of new sequences is an active process in which natural code-using agents produce new sequences in vivo.

This short description of the essentials of biocommunication contradicts former opinions of communication in natural sciences, information theory, systems theory, mechanistic and reductionistic approaches which rely on a mathematical theory of language, i.e., concepts of quantifiable sets of signs. The history of the philosophy of science clearly demonstrates a variety of such approaches in which signals are molecules which are subject to quantitative investigations and comparisons usually based on investigations of the molecular syntax structure of the natural codes. This means that molecular syntax as a result of chance mutations (error replications) and selection represents the material reality of the physicochemical world which can best be represented by mathematical equations. In this perspective, material reality is the only reality because it can be objectivized, measured, and empirically investigated. The molecular syntax of natural codes is therefore the information-bearing content out of which its functions and its meaning can be distilled.

Yet this paradigm was falsified in the 1980s by pragmatic philosophy and sociology which empirically tested that meaning was not represented by the syntax structure of natural codes, but by the context in which sign sequences are used by in vivo interactions of living agents. In contrast to the former narrative, pragmatics (context) determines the meaning of sign sequences, with the consequence that identical sequences of signs may transport different meanings, even contradictory ones. This makes sense in light of energy costs: It is not necessary to represent an ontological entity or event by unequivocal representations. One sign sequence can designate multiple meanings according to contextual needs. A sign- and rule-sharing population only needs a limited number of signals and a limited number of rules to produce multiple variant communications; even de novo generation, although rare, is possible in principle.

This means it is not the syntax which is the relevant information for extracting the meaning of signals used to coordinate and organize behavior. To avoid the term "meaning," Francis Crick wanted to use "Information" only in a strict mechanistic way ("*'Information' in the DNA, RNA, protein sense is merely a convenient shorthand for the underlying causal effect. As to "meaning" ... I would keep away from the term.*").

In contrast to this perspective, it is the context in which social interactions occur, i.e., that in which signs and sign sequences are used. This means the sociological aspect is essential for deciphering the meaning of natural codes.

Biocommunication processes have been documented meanwhile on the whole area of living nature, i.e., plants, animals, fungi, akaryotes, viruses, and even RNA consortia. One missing publication on communication of archaea is presented here. The published works on biocommunication are not the end but the start of a coherent process of investigations and data mining regarding communicative actions within cells, between cells and between non-related organisms during the whole biosphere, and could lead to a better understanding of the principles governing living nature and a better picture of life on this planet to restructure the behavioral motifs of humankind in its relation to non-human living nature.

The benefit of this new type of research which integrates empirically derived knowledge about archaea physics and chemistry with pragmatic action theory is its more coherent explanatory power. It complements the current knowledge about the physiology of archaea and motifs on each level of archaeal life with the available habitats and contexts in which archaea species live. In contrast to pure reductionistic biology, it can integrate the basic motifs of archaea signaling within varying contexts with the knowledge about all physiological interactions. In contrast to mechanistic biology—it only recalls on the outdated narrative of "information" transfer—the biocommunication approach focuses on the real-life situations in which signaling directs the various forms of interaction. In this context, communication is not restricted to information transfer but predominantly acts as a kind of social interaction.

Finally, the editor hopes that Biocommunication of Archaea will integrate a diversity of research goals on the function, taxonomy, and genetics of archaea, representing their main principles of life, evolution, and developmental stages. Understanding the full range of archaea life will have repercussions for the understanding of life and its evolution in general.

Bürmoos, Austria Guenther Witzany
May 2017

Acknowledgements

I am grateful to all authors that contributed to the success of the biocommunication book series:

Biocommunication in Soil Microorganisms (2011)

Stephen T. Abedon, Robert Armon, Susumu Asakawa, Mina Aziz, Omar Bagasra, Eshel Ben-Jacob, Emilie Chapelle, Alan J. Castle, Miguel A. Cevallos, Brian Cheetham, Yves Dessaux, Denis Faure, Mengsheng Gao, Margaret E. Katz, Dror Y. Kenett, Mi-Seong Kim, Makoto Kimura, S. Krishnaswamy, Susan M. Lehman, Asaf Madi, Massimo Merighi, Paul Murugan, Natsuko Nakayama, Ralf Oelmüller, Katherine M. Pappas, D. Gene Pace, Paul W. Paré, Ilona Pfeiffer, Meghna Pohani, Sathish Rajamani, Margaret A. Riley, Dwayne Roach, Jayne Robinson, Dalit Roth, Xin Shen, Irena Sherameti, Peter Sholberg, Neeraj Shrivastava, Shashibala Sing, K.V. Srividhya, Antonet M. Svircev, Max Teplitski, Michael Ting, Kailash C. Upadhayaya, Ajit Varma, Guanghua Wang, Kurt E. Williamson, Gabriele Whittle, Xitao Xie, Huiming Zhang, Jinlin Zhang.

Biocommunication of Plants (2012)

Juan M. Alba, Silke Allmann, Dirk Balmer, Frantisek Baluska, David Mc.K.Bird, Janet Braam, Ana Victoria Carcia, Amélie Charrier, E.Wassim Chehab, Peter M. DiGennaro, Sylvie Dinant, Jurgen Engelberth, Balaji Enugutti, Nancy A. Fujishige, Joris J. Glas, Heribert Hirt, Ann M. Hirsch, Angela Hodge, Marco Kai, Ulrich Melcher, Merijin R. Kant, Daniel K. Manter, Brigitte Mauch-Mani, Miyo Terao Moirta, Moritaka Nakamura, Moritz K. Nowack, Yadira Olvera-Carillo, Birgit Piechulla, Gadi V.P. Reddy, Bernardus C.J. Schimmel, Yuliya Salanenka, Adam

Schikora, Eleni A. Spyropoulou, Marije Stoops, Akifumi Sugiyama, Kay Schneitz, Georg J. Seifert, Paula Suarez López, Masao Tasaka, Anthony Trewawas, Claudio Valverde, Carlos Villarroel, Jorge M. Vivanco, Katrin Wenke, Teresa Weise, Rene Warnke, Dierk Wanke, Krystof Wieczorek.

Biocommunication of Fungi (2012)

Katharyn J. Affeldt, Audrey L. Atkin, Andrey A. Averyanov, Drion G. Boucias, Jeremy Bruenn, Katherine A. Borkovich, Tatiana A. Belozerskaya, Maria C. Bertolini, Eli J. Borrego, Renato M. de Paula, Asharie J. Campbell, Robert Cichewicz, Fernanda B. Cupertino, Aurelie Deveau, Anna A. Fabbri, Corrado Fanelli, Fernanda Z. Freitas, Pascale Frey-Klett, N. Louise Glass, Natalie N. Gessler, Rodrigo D. Goncalves, Jessica C. Hargarten, Sahar Hasim, Elizabeth A. Hutchison, Alexander Idnurm, Nancy P. Keller, Michael V. Kolomiets, Valerie Legue, Verena U. Litze, Francis Martin, John P. Morrissey, Jonathan M. Plett, Tatiana Potapova, Zdena Palkova, Libuse Vachova, Philippe Silar, Silvia Polaino, Kenneth W. Nickerson, Ruvini Pathirana, Massimo Reverberi, Rusty J. Rodriguez, Marilyn Roossinck, Jacqueline A. Severin, David R. Soll, Danielle M. Troppens, Peter Teal.

Viruses: Essential Agents of Life (2012)

Chantal Abergel, Alessia Armezzani, Frédérick Arnaud, Nina S. Atanasova, Omar Bagasra, Dennis H. Bamford, Pierre-Adrien Bolze, Harald Brüssow, Domitille Chalopin, Jean-Michel Claverie, Elena Capel, Angela Ciuffi, Michael Chandler, Philippe Colson, Andrew B. Conley, Sébastien Desfarges, Jonathan Fileé, Sandro Franco, Patrick Forterre, Delphine Galiana, Matthew Haynes, Matti Jalasvuori, I. King Jordan, Mart Krupovic, Hanna M. Oksanen, Donald G. Pace, Massimo Palmarini, Mariona Parera, Philippe Pérot, Maija K. Pietilä, Elina Roine, Francois Mallet, Miguel Angel Martinez, Gloria Martrus, Lita Murphy, Maria Nevot, Didier Raoult, Forest Rohwer, Marilyn J. Roossinck, Ana Sencilo, Muhammad Sheraz, Thomas E. Spencer, Marta Tomaszkiewicz, Rachael E. Tarlinton, Jean-Nicolas Volff, Luis P. Villarreal, Merry Youle.

Biocommunication of Animals (2014)

Piero Amodio, Gustavo Arriaga, Stefan M. Brudzynski, Ana Maria Costa-Leonardo, Shermin de Silva, Tamas Farago, Camila R. Ferrara, Graziano Fiorito, Jacqueline C. Giles, Ives Haifig, Kenji Hara, Lynne D. Houck, Yen-Ping

Hsueh, Mary Lee A. Jensvold, Gerald Kuchling, Walter Lechner, Daniel H.W. Leighton, Pierre Madl, John M. Marzluff, Marc L. Miller, Marc Naguib, Irene Pepperberg, Giovanna Ponte, Jan Randall, Friedericke Range, Katharina Riebel, Laela Sayigh, Savannah M. Schulze, Ulricke Siebeck, Paul W. Sternberg, Angela Stöger, Simon Townsend, Elena Tricarico, Richard C. Vogt, Lisa Wilding.

Biocommunication of Ciliates (2016)

Takahiko Akematsu, Claudio Alimenti, Sarah Allen, John B. Bracht, Kathryn A. Bracht, Yelena Bisharyan, Wendy Ashlock, Takahiko Akematsu, Eric S. Cole, Jean Clobert, Alexis S. Chaine, Deanna Cho, Wie-Jen Chang, Theodore Clark, György Csaba, Emily M. Ferraro,, Arno Germond, Masahiro Fujishima, Stafan Jacob, Yuuki Kodama, Laszlo Köhidai, Delphine Legrand, Christopher S. Lobban, Pierangelo Luporini, Mariusz Nowacki, Toshiyuki Nakajima, Helmut Plattner, Bill Pedrini, Ronald Pearlman, Birgit H. Satir, Peter Satir, Nicolas Schtickzelle, Maria Schefter, Bettina Sonntag, Adriana Vallesi, Thomas Weisse, Kassandra E. Zaila, Rebecca A. Zufall.

Biocommunication of Archaea (2017)

Stephen T. Abedon, Sonja-Verena Albers, Fayez Aziz, Manuel Becerra, Charlotte Beloe, Carol Bernstein, Harris Bernstein, Christian Brininger, Brendan P. Burns, Derek Caetano-Anollés, Gustavo Caetano-Anollés, Kelsey Caetano-Anollés, James C. Charlesworth, Lori Cobani, Daniel Colman, Juan-José Escuder-Rodríguez, Caryn Evilia, Xu Feng, J. Peter Gogarten, María-Isabel González-Siso, Wenyuan Han, Peter J. Kennelly, Kyung Mo Kim, Ibrahim Koç, Eugene V. Koonin, Yuchen Liu, Zuhong Lu, Kira S. Makarova, Bushra F. Minhas, Jay E. Mittenthal, Tomohiro Mochizuki, Fizza Mughal, Arshan Nasir, Alvaro Orell, David Penny, Tessa E.F. Quax, Lennart Randau, Esther Rodríguez-Belmonte, Simone Schopf, Khuram Shahzad, Qunxin She, Shannon M. Soucy, Savannah Spradlin, D. Swati, Guy Tal, Masaharu Takemura, Mario Vera, Shengqin Wang, Cara Watters, Cuiping Zhao.

Contents

Contributors

Stephen T. Abedon Department of Microbiology, The Ohio State University, Mansfield, OH, USA

Sonja-Verena Albers Molecular Biology of Archaea, Institute for Biology II, Faculty of Biology, University of Freiburg, Freiburg, Germany

Fayez Aziz Department of Crop Sciences, University of Illinois, Urbana, IL, USA

Manuel Becerra Grupo EXPRELA, Centro de Investigacións Científicas Avanzadas (CICA), Departamento de Bioloxía Celular e Molecular, Facultade de Ciencias, Universidade da Coruña, A Coruña, Spain

Carol Bernstein Department of Cellular and Molecular Medicine, College of Medicine, University of Arizona, Tucson, AZ, USA

Harris Bernstein Department of Cellular and Molecular Medicine, College of Medicine, University of Arizona, Tucson, AZ, USA

Charlotte Beloe School of Biotechnology and Biomolecular Sciences, University of New South Wales, Sydney, Australia; Australian Centre for Astrobiology, University of New South Wales, Sydney, NSW, Australia

Christian Brininger Department of Chemistry, Idaho State University, Pocatello, ID, USA

Brendan P. Burns School of Biotechnology and Biomolecular Sciences, University of New South Wales, Sydney, Australia; Australian Centre for Astrobiology, University of New South Wales, Sydney, NSW, Australia

Derek Caetano-Anollés Department of Evolutionary Genetics, Max-Planck-Institut Für Evolutionsbiologie, Plön, Germany

Gustavo Caetano-Anollés Department of Crop Sciences, University of Illinois, Urbana, IL, USA; Illinois Informatics Institute, University of Illinois, Urbana, IL, USA

Kelsey Caetano-Anollés Department of Agricultural Biotechnology and Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea

James C. Charlesworth School of Biotechnology and Biomolecular Sciences, University of New South Wales, Sydney, Australia; Australian Centre for Astrobiology, University of New South Wales, Sydney, NSW, Australia

Lori Cobani Department of Chemistry, Idaho State University, Pocatello, ID, USA

Daniel R. Colman Department of Microbiology & Immunology, Montana State University, Bozeman, MT, USA

María-Eugenia DeCastro Grupo EXPRELA, Centro de Investigacións Científicas Avanzadas (CICA), Departamento de Bioloxía Celular e Molecular, Facultade de Ciencias, Universidade da Coruña, A Coruña, Spain

Juan-José Escuder-Rodríguez Grupo EXPRELA, Centro de Investigacións Científicas Avanzadas (CICA), Departamento de Bioloxía Celular e Molecular, Facultade de Ciencias, Universidade da Coruña, A Coruña, Spain

Caryn Evilia Department of Chemistry, Idaho State University, Pocatello, ID, USA

Xu Feng Department of Biology, University of Copenhagen, BioCenter, Copenhagen N, Denmark

J. Peter Gogarten University of Connecticut, Storrs, CT, USA

María-Isabel González-Siso Grupo EXPRELA, Centro de Investigacións Científicas Avanzadas (CICA), Departamento de Bioloxía Celular e Molecular, Facultade de Ciencias, Universidade da Coruña, A Coruña, Spain

Wenyuan Han Department of Biology, University of Copenhagen, BioCenter, Copenhagen N, Denmark

Peter J. Kennelly Department of Biochemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA

Kyung Mo Kim Division of Polar Life Sciences, Korea Polar Research Institute, Incheon, Republic of Korea

Ibrahim Koç Department of Crop Sciences, University of Illinois, Urbana, IL, USA; Molecular Biology and Genetics, Gebze Technical University, Kocaeli, Turkey

Eugene V. Koonin National Center for Biotechnology Information, National Library of Medicine, Bethesda, MD, USA

Yuchen Liu Department of Biological Sciences, Louisiana State University, Baton Rouge, LA, USA

Zuhong Lu State Key Lab of Bioelectronics, School of Biological Science and Medical Engineering, Southeast University, Nanjing, China

Kira S. Makarova National Center for Biotechnology Information, National Library of Medicine, Bethesda, MD, USA

Bushra F. Minhas Department of Crop Sciences, University of Illinois, Urbana, IL, USA; Illinois Informatics Institute, University of Illinois, Urbana, IL, USA

Jay E. Mittenthal Department of Cell and Developmental Biology, University of Illinois, Urbana, IL, USA

Tomohiro Mochizuki Earth-Life Science Institute, Tokyo Institute of Technology, Tokyo, Japan

Fizza Mughal Department of Crop Sciences, University of Illinois, Urbana, IL, USA; Illinois Informatics Institute, University of Illinois, Urbana, IL, USA

Arshan Nasir Department of Crop Sciences, University of Illinois, Urbana, IL, USA; Department of Biosciences, COMSATS Institute of Information Technology, Islamabad, Pakistan

Alvaro Orell Max Planck Institute for Terrestrial, Marburg, Germany

David Penny Institute of Fundamental Sciences, Massey University, Palmerston North, New Zealand

Tessa E.F. Quax Molecular Biology of Archaea, Institute for Biology II, Faculty of Biology, University of Freiburg, Freiburg, Germany

Lennart Randau Max Planck Institute for Terrestrial, Marburg, Germany

Esther Rodríguez-Belmonte Grupo EXPRELA, Centro de Investigacións Científicas Avanzadas (CICA), Departamento de Bioloxía Celular e Molecular, Facultade de Ciencias, Universidade da Coruña, A Coruña, Spain

Simone Schopf Institute of Biosciences, Environmental Microbiology, Technische, Universität Bergakademie Freiberg, Freiberg, Germany

Khuram Shahzad Illinois Informatics Institute, University of Illinois, Urbana, IL, USA

Qunxin She Department of Biology, University of Copenhagen, BioCenter, Copenhagen N, Denmark

Shannon M. Soucy Dartmouth College, Hanover, USA

Savannah Spradlin Department of Chemistry, Idaho State University, Pocatello, ID, USA

D. Swati Department of Physics and Bioinformatics, MMV, Banaras Hindu University, Varanasi, India

Masaharu Takemura Laboratory of Biology, Department of Liberal Arts, Faculty of Science, Tokyo University of Science, Tokyo, Japan

Guy Tal Department of Crop Sciences, University of Illinois, Urbana, IL, USA

Mario Vera Institute for Biological and Medical Engineering, Schools of Engineering, Medicine and Biological Sciences, Department of Hydraulic and Environmental Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile

Shengqin Wang College of Life and Environmental Science, Wenzhou University, Wenzhou, China

Cara Watters School of Biotechnology and Biomolecular Sciences, University of New South Wales, Sydney, Australia; Australian Centre for Astrobiology, University of New South Wales, Sydney, NSW, Australia

Guenther Witzany Telos-Philosophische Praxis, Buermoos, Austria

Cuiping Zhao Department of Biological Sciences, Louisiana State University, Baton Rouge, LA, USA