

# Probiotics and Prebiotics

Current Research and Future Trends

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# Current Books of Interest

Microalgae: Current Research and Applications	2016
Arboviruses: Molecular Biology, Evolution and Control	2016
<i>Shigella</i> : Molecular and Cellular Biology	2016
Aquatic Biofilms: Ecology, Water Quality and Wastewater Treatment	2016
Alphaviruses: Current Biology	2016
Thermophilic Microorganisms	2015
Flow Cytometry in Microbiology: Technology and Applications	2015
Epigenetics: Current Research and Emerging Trends	2015
<i>Corynebacterium glutamicum</i> : From Systems Biology to Biotechnological Applications	2015
Advanced Vaccine Research Methods for the Decade of Vaccines	2015
Antifungals: From Genomics to Resistance and the Development of Novel Agents	2015
Bacteria-Plant Interactions: Advanced Research and Future Trends	2015
<i>Aeromonas</i>	2015
Antibiotics: Current Innovations and Future Trends	2015
<i>Leishmania</i> : Current Biology and Control	2015
<i>Acanthamoeba</i> : Biology and Pathogenesis (2nd edition)	2015
Microarrays: Current Technology, Innovations and Applications	2014
Metagenomics of the Microbial Nitrogen Cycle: Theory, Methods and Applications	2014
Pathogenic <i>Neisseria</i> : Genomics, Molecular Biology and Disease Intervention	2014
Proteomics: Targeted Technology, Innovations and Applications	2014
Biofuels: From Microbes to Molecules	2014
Human Pathogenic Fungi: Molecular Biology and Pathogenic Mechanisms	2014
Applied RNAi: From Fundamental Research to Therapeutic Applications	2014
Halophiles: Genetics and Genomes	2014
Molecular Diagnostics: Current Research and Applications	2014
Phage Therapy: Current Research and Applications	2014
Bioinformatics and Data Analysis in Microbiology	2014
The Cell Biology of Cyanobacteria	2014
Pathogenic <i>Escherichia coli</i> : Molecular and Cellular Microbiology	2014
<i>Campylobacter</i> Ecology and Evolution	2014
<i>Burkholderia</i> : From Genomes to Function	2014
Myxobacteria: Genomics, Cellular and Molecular Biology	2014
Next-generation Sequencing: Current Technologies and Applications	2014
Omics in Soil Science	2014
Applications of Molecular Microbiological Methods	2014
<i>Mollicutes</i> : Molecular Biology and Pathogenesis	2014

# Preface

Probiotics and prebiotics have received increasing attention over the past few decades as ways to increase the health of the host. The definitions of both probiotics and prebiotics include a 'health benefit for the host', which is why regulatory bodies do not allow the use of the phrases on commercial products. These organizations are not (yet) convinced by the ever growing evidence that shows the benefit of the exogenous beneficial microbes (probiotics) or the compounds (prebiotics) that selectively increase the numbers and/or activity of the endogenous beneficial microbes in our gut. Despite the reservation by regulatory bodies to allow the use of these words, scientists still use the phrases in scientific publications when a benefit to the host has been shown. Significant advances have been made in recent years in the development of products with probiotics and/or prebiotics to prevent

numerous diseases and disorders. Here, after a brief introduction to the field, first the different probiotic genera are discussed. Next, topics related to prebiotics are highlighted. Furthermore, effects of probiotics and prebiotics on health are included, focusing on areas in which these dietary ingredients have recently been used. Finally, an outlook to the future is given. The contributions take a critical view on the evidence for health benefits of probiotics and prebiotics. The authors are believers, although we remain critical about certain aspects of the research, such as dose, duration of intake, combinations of probiotics, and combination of probiotics with prebiotics. Nevertheless, we believe there is a future for these health beneficial components of the diet as natural ways to combat the diseases and disorders that perturb our modern society.

Koen Venema and Ana Paula do Carmo

# Appendix I: Web Resources

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## Chapter 1

- FSTA®:
  - an intelligence service constantly monitoring developments in the areas of food science, food technology and nutrition
  - <http://www.foodsciencecentral.com/>
- IFIC (International Food Information Council Foundation):
  - dedicated to the mission of effectively communicating science-based information on health, nutrition and food safety for the public good
  - <http://www.foodinsight.org/>
- FAO/WHO views on probiotics:
  - [http://www.who.int/foodsafety/publications/fs\\_management/en/probiotics.pdf](http://www.who.int/foodsafety/publications/fs_management/en/probiotics.pdf)
  - [http://www.who.int/foodsafety/fs\\_management/en/probiotic\\_guidelines.pdf?ua=1](http://www.who.int/foodsafety/fs_management/en/probiotic_guidelines.pdf?ua=1)
- International Life Sciences Institute (ILSI) task-force on probiotics:
  - [http://www.ilsi.org/Europe/Pages/TF\\_Probiotics.aspx](http://www.ilsi.org/Europe/Pages/TF_Probiotics.aspx)
- ILSI task-force on prebiotics:
  - [http://www.ilsi.org/Europe/Pages/TF\\_Probiotics.aspx](http://www.ilsi.org/Europe/Pages/TF_Probiotics.aspx)
- ISAPP (International Scientific Association for Probiotics and Prebiotics):
  - <http://www.isapp.net/>
- American Gut:
  - World's largest open-source science project to understand the microbial diversity of the Human Gut.
  - Learn which microbes live in your gut, skin and mouth
  - <http://humanfoodproject.com/americangut/>

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## Chapter 2

- KEGG pathway:
  - an on-line database for wiring diagrams of molecular interactions, reactions, and relations
  - <http://www.genome.jp/kegg/pathway.html>
- The Human Metabolome Database (HMDB):
  - a freely available electronic database containing detailed information about small molecule metabolites found in the human body
  - <http://www.hmdb.ca/>

- The International Association for Probiotics and Prebiotics (ISAPP):
  - an international non-profit collaboration of scientists dedicated to advance scientific excellence in probiotics and prebiotics
  - <http://www.isapp.net/Probiotics-and-Prebiotics/The-Science>

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## Chapter 4

### Bacterial genome sequences

The following sites contain genome sequence information of *Bifidobacterium*; some searching may be required:

- <http://www.ebi.ac.uk/genomes/bacteria.html>
- [http://www.ncbi.nlm.nih.gov/genomes/MICROBES/microbial\\_taxtree.html](http://www.ncbi.nlm.nih.gov/genomes/MICROBES/microbial_taxtree.html)
- <http://www.genomesonline.org/organisms?Organism.Domain=BACTERIAL>

Societies promoting the science behind *Bifidobacterium*:

- International Scientific Association for Probiotics and Prebiotics: <http://www.isapp.net/>
- International Probiotics Association: <http://www.internationalprobiotics.org/about>
- Global Alliance for Probiotics: <http://www.gap-probiotics.org/>
- International Life Sciences Institute: [http://www.ilsi.org/Europe/Pages/TF\\_Probiotics.aspx](http://www.ilsi.org/Europe/Pages/TF_Probiotics.aspx)

Sources of general information regarding probiotics:

- American Nutrition Association: <http://americannutritionassociation.org/newsletter/science-probiotics>
- American Gastroenterological Association: <http://www.gastro.org/patient-center/diet-medications/probiotics>



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**Chapter 5**

- Accurate information about the current status of a name, synonyms, and other useful information concerning prokaryotes:
  - <http://www.bacterio.net/propionibacterium.html>
- General information from MicrobeWiki, the student-edited microbiology resource:
  - <https://microbewiki.kenyon.edu/index.php/Propionibacterium>
- Web page of the International Scientific Association for Probiotics and Prebiotics showing general information related to scientific advances in probiotics and prebiotics:
  - <http://www.isapp.net/>

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**Chapter 6****Functional foods**

- <http://www.isabellashealthybakery.com/functional.html>
- <http://www.sporegen.com>
- <http://www.sabinsa.com/newsroom/press-releases/pr20121002.html>

**Probiotics manufacturers**

- <http://www.ganedenBC30.com>

**EFSA Journal**

- [www.efsa.europa.eu/efsajournal](http://www.efsa.europa.eu/efsajournal)
- <http://www.efsa.europa.eu/it/efsajournal/pub/773.htm>

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**Chapter 7**

- <http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2036.2007.03442.x/pdf>
- <http://www.dairyscience.info/index.php/probiotics/232-yeast-probiotics.html>
- <http://www.europeanreview.org/wp/wp-content/uploads/1000.pdf>

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**Chapter 8****Animals**

- EFSA: Additives and Products or Substances used in Animal Feed (FEEDAP)
  - <http://www.efsa.europa.eu/en/panels/feedap.htm>
- American Association of Feed Control Officials: Ingredient Definitions Committee
  - <http://www.aafco.org/Directory/CommitteePages/IngredientDefinitions.aspx>

**Humans**

- EFSA: Opinion on the Qualified Presumption of Safety on selected microorganisms
  - <http://www.efsa.europa.eu/en/efsajournal/doc/587.pdf>
- EFSA: Substantiation of health claims related to non-characterized bacteria and yeasts
  - <http://www.efsa.europa.eu/en/efsajournal/doc/1470.pdf>

- National Center for Complementary and Alternative Medicine: Oral Probiotics
  - <http://nccam.nih.gov/health/probiotics/introduction.htm>
- US Food and Drug Administration: Regulatory perspectives on pre- and probiotics
  - <http://www.iom.edu/~media/Files/Activity%20Files/PublicHealth/MicrobialThreats/Vaillaincourt17Mar05ProbioticsRegulation.pdf>
- Agriculture and Agri-Food Canada: Function claims and probiotic claims for food
  - [http://www4.agr.gc.ca/resources/prod/doc/prog/ai-ae/pdf/probiotics\\_probiotiques\\_eng.pdf](http://www4.agr.gc.ca/resources/prod/doc/prog/ai-ae/pdf/probiotics_probiotiques_eng.pdf)
- FAO/WHO: Probiotic definition
  - <ftp://ftp.fao.org/docrep/fao/009/a0512e/a0512e00.pdf>

**Trade Associations**

- International Probiotics Association
  - <http://www.internationalprobiotics.org/about>
- International Scientific Association for Probiotics and Prebiotics.
  - <http://www.isapp.net/>

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**Chapter 9**

General information about *E. coli* infections and outbreaks can be found at the following websites:

- World Health Organization:
  - [http://www.who.int/topics/escherichia\\_coli\\_infections/en/](http://www.who.int/topics/escherichia_coli_infections/en/)
- Centers for Disease Control and Prevention (USA government):
  - <http://www.cdc.gov/ecoli/>
- European Centre for Disease Prevention and Control:
  - [http://ecdc.europa.eu/en/healthtopics/escherichia\\_coli/pages/index.aspx](http://ecdc.europa.eu/en/healthtopics/escherichia_coli/pages/index.aspx)
- About *E. coli*:
  - <http://www.about-ecoli.com/>

Genome databases and tools for colibiome analysis can be found at the following websites:
- Pathosystems Ressource integration Center (PATRIC):
  - <http://patricbrc.org/portal/portal/patric/Taxon?cType=taxon&cId=561>
- Virulence Factors of pathogenic Bacteria (VFDB-comparative pathogenomics):
  - <http://www.mgc.ac.cn/cgi-bin/VFs/compvfs.cgi?Genus=Escherichia>
- *E. coli* Database portal:
  - <http://www.uni-giessen.de/ecoli/IECA/index.php>
- -Colibri and Genolist World-Wide Web server (Institut Pasteur):
  - <http://genolist.pasteur.fr/Colibri/>
  - <http://genodb.pasteur.fr/cgi-bin/WebObjects/GenoList.woa/1/wa/goToTaxoRank?level=Escherichia>

- *E. coli* genome project (University of Wisconsin):
  - <http://www.genome.wisc.edu/>
 Web resources related to MLST analysis according to the three main schemes are provided by the following sites:

- A multilocus sequence typing database system for pathogenic *E. coli* (EcMLST):
  - <http://shigatox.net/new/tools/ecmlst.html>
- Institut Pasteur's MLST website:
  - [www.pasteur.fr/mlst](http://www.pasteur.fr/mlst)
- Achtman scheme:
  - <http://mlst.warwick.ac.uk/mlst/dbs/Ecoli>
 General information, newsletters about gut microbiota and probiotics and impact on health:

- The gut Microbiota for Health:
  - <http://www.gutmicrobiotaforhealth.com/>
  - <http://gutmicrobiotaforhealth.com/c/probiotics>
- Metahit, the human gut genes catalogue:
  - <http://www.metahit.eu/index.php?id=360>
- Metagenopolis:
  - <http://www.mgps.eu/index.php?id=homepage>
- ISAP (International Scientific Association for Probiotics and Prebiotics):
  - <http://www.isapp.net>
- Probiotics: Applications in Gastrointestinal Health and Disease:
  - <http://www.usprobiotics.org>
 Information related to probiotic preparations containing *E. coli* strains can be found at the following websites:

- Mutaflor®:
  - <http://www.mutaflor.de/cms/> (German site)
  - <http://mutaflor.ca/> (Canadian site)
  - <http://mutaflor.com.au/> (Australian site)
- Symbioflor®2:
  - <http://symbiopharm.de/en/products/symbioflor-2.html>
- Colinfant newborn:
  - [http://dyntec.cz.s3.amazonaws.com/232\\_eng\\_colinfantnb.pdf](http://dyntec.cz.s3.amazonaws.com/232_eng_colinfantnb.pdf)
 Database related to clinical studies of human participants conducted around the world are available at the following website:

- <http://clinicaltrials.gov/ct2/home>

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## Chapter 11

### GMO

- <http://www.hse.gov.uk/biosafety/gmo/information.htm>
- <http://www.efsa.europa.eu/en/panels/gmo.htm>

### Company

- <http://www.actogenix.com/>
- <http://www.vitherapharma.com/index.html>

### Clinical trial

- <https://clinicaltrials.gov/>
- International Scientific Association for Probiotics and Prebiotics:
  - <http://www.isapp.net/>

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## Chapter 12

- Metahit homepage:
  - <http://www.metahit.eu/>
- American Human Microbiome Project home page:
  - <http://commonfund.nih.gov/hmp/index>
- Vaginal microbiome consortium:
  - <http://vmc.vcu.edu/about>
- Mediateque INRA:
  - <http://mediatheque.inra.fr/media/detail/246161/private>
- Micalis homepage:
  - [http://www.micalis.fr/micalis\\_eng/](http://www.micalis.fr/micalis_eng/)
- CDC page for IBD:
  - <http://www.cdc.gov/ibd/>
- Chrons and colitis foundation of America:
  - <http://www.ccfa.org/>
- What is a health benefit? Researchers issue probiotic guidance for EFSA applications. By Nathan Grey+, 11-Sep-2013:
  - <http://www.nutraingredients.com/Research/What-is-a-health-benefit-Researchers-issue-probiotic-guidance-for-EFSA-applications>
- Analytical Profile Index Biomerieux homepage:
  - [http://www.biomerieux-usa.com/servlet/srt/bio/usa/dynPage?doc=USA\\_PRD\\_LST\\_G\\_PRD\\_USA\\_5](http://www.biomerieux-usa.com/servlet/srt/bio/usa/dynPage?doc=USA_PRD_LST_G_PRD_USA_5)

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## Chapter 14

### Science Sites

- Centro de Referencia para Lactobacilos:
  - <http://www.cerela.org.ar/>
  - The Dairy Institute of Tucuman belongs to National Scientific and Technical Research Council -Argentina.
- Center for Gastrointestinal Biology and Disease:
  - <http://www.med.unc.edu/cgibd>
- Instituto de Productos Lácteos de Asturias:
  - <http://www.ipla.csic.es/>
  - The Dairy Institute of Asturias belongs to Science and Food Technology Higher Council for Scientific Research.
- Laboratory of Microbiology Wageningen:
  - <http://www.wageningenur.nl/en/Expertise-Services/Chair-groups/Agrotechnology-and-Food-Sciences/Laboratory-of-Microbiology.htm>
- Microbiome Core Facility:
  - <http://www.med.unc.edu/microbiome>
  - metagenomic technologies to examine microbial communities
- Southeast Dairy Foods Research Center:
  - <http://fbns.ncsu.edu/sdfrc/sdfrc.html>

- The SDFRC has been in operation since 1988. North Carolina State University is the lead institution, joined by Mississippi State University. It is one of six National Centers funded and supported by Dairy Management Inc. (DMI), through the Dairy Research Institute (DRI).

### Company sites

- American Type Culture Collection (ATCC):
  - <http://www.atcc.org/>
- Chr. Hansen:
  - <http://www.chr-hansen.com/research-development/customization.html>
  - development of bacterial cultures for the dairy industry.
- BioGaia is a Swedish company:
  - <http://www.biogaia.com/>
- BIOPOLIS, S.L | Tailor-made Biotechnology:
  - <http://www.biopolis-biotech.com/en/agri-food-biotechnology/>
- BioSidus Probiótico intestinal (Bioflora™):
  - <http://www.biosidus.com.ar/biopharmaceuticals.php>
- Food for Health Ireland:
  - <http://www.fhi.ie/home/>
- Lactina-ltd:
  - <http://www.lactina-ltd.com/eng/products-zakvaski.php>
- Lactosan GmbH and Co. KG manufacturers of products based on living lactic acid bacteria:
  - <http://www.lactosan.at/company.en.34.htm>
- Lalleman:
  - <http://www.lallemand.com/>
- Nestle Institute Health Sciences Lausanne:
  - <http://www.nestleinstitutehealthsciences.com/>
- TI Food Nutrition:
  - <http://www.tifn.nl/partnershipforinnovation>

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### Chapter 15

- KEGG:
  - Kyoto Encyclopedia of Genes and Genomes
  - <http://www.genome.jp/kegg/>
- CAZy:
  - Carbohydrate-Active enZYmes Database
  - <http://www.cazy.org/>
- HMP:
  - Human Microbiome Project
  - <http://www.hmpdacc.org/>
- MetaHIT:
  - Metagenomics of the Human Intestinal Tract
  - <http://www.metahit.eu/>
- RegPrecise:
  - Collection of Manually Curated Inferences of Regulons in Prokaryotic Genomes
  - <http://regprecise.lbl.gov/RegPrecise/>
- PharmacoMicrobiomics:
  - The Drug-Microbiome Portal
  - <http://pharmacomicrobiomics.com/>
- mPUMA:

- microbial Profiling Using Metagenomic Assembly
- <http://mpuma.sourceforge.net>
- BioCyc:
  - a collection of 2988 Pathway/Genome Databases
  - <http://biocyc.org/>
- MetaCyc:
  - a database of nonredundant, experimentally elucidated metabolic pathways
  - <http://www.metacyc.org/>
- Pathway Tools:
  - a comprehensive symbolic systems biology software system that supports several use cases in bioinformatics and systems biology
  - <http://brg.ai.sri.com/ptools/>
- American Gut:
  - World's largest open-source science project to understand the microbial diversity of the Human Gut. Learn which microbes live in your gut, skin and mouth
  - <http://humanfoodproject.com/americangut/>
- Rob Knight Lab, University of Colorado – Software:
  - [https://knightlab.colorado.edu/wordpress/?page\\_id=28](https://knightlab.colorado.edu/wordpress/?page_id=28)
- HMDB:
  - Human Metabolome Database
  - <http://www.hmdb.ca/>
- G6G:
  - Directory of Omics and Intelligent Software! This software directory lists data mining and additional software from the fields of biotechnology and artificial intelligence
  - <http://g6g-softwaredirectory.com/index.php>

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### Chapter 16

- <http://qiime.org/>:
  - Quantitative Insights into Microbial Ecology or QIIME is an open source software package used to compare and analyse microbial communities, usually using 16S rRNA gene or metagenomics NGS data generated from different platforms
- <http://www.microbial-ecology.net/probebase/credits.asp>:
  - the Department of Microbial Ecology at the University of Vienna runs probeBase, a database housing oligonucleotide probes usually targeting 16S rRNA and used for fluorescent *in situ* hybridization
- <http://www.arb-silva.de/SILVA> rRNA database:
  - an on-line resource ribosomal RNA (both large and small unit rRNA) sequence data
- <http://rdp.cme.msu.edu/RDP>:
  - **an on-line resource ribosomal RNA (both large and small unit rRNA) sequence data**
- <http://greengenes.lbl.gov/cgi-bin/nph-index.cgi>:
  - a web application providing access to the greengenes 16S rRNA gene sequence alignment for browsing, blasting, probing, and downloading
- <http://www.hmpdacc.org/>:
  - stores all the protocols, computational methods, and the results produced by the Human Microbiome Project.

## Chapter 17

Table I.1 Resources available for metagenomic analysis

Type	Resource	Features	Website	Reference
Reference sequence DB	Greengenes	Quality-controlled microbial DNA data and tools	<a href="http://greengenes.lbl.gov/cgi-bin/nph-index.cgi">http://greengenes.lbl.gov/cgi-bin/nph-index.cgi</a>	DeSantis <i>et al.</i> (2006)
	SILVA	Quality checked and regularly updated datasets	<a href="http://www.arb-silva.de/">http://www.arb-silva.de/</a>	Pruesse <i>et al.</i> (2007), Quast <i>et al.</i> (2013)
	RDP	Online data analysis, rRNA derived phylogenetic trees, aligned and annotated rRNA sequences	<a href="http://rdp.cme.msu.edu/">http://rdp.cme.msu.edu/</a> <a href="https://github.com/rdpstaff">https://github.com/rdpstaff</a>	Cole <i>et al.</i> (2009)
Annotation and analysis tools	MG-RAST (MetaGenomics Rapid Annotator using Subsystem)	Annotation, taxonomic and functional assignment, pathway reconstruction single platform (depositing, locating, analysing, visualizing, data sharing)	<a href="http://metagenomics.nmpdr.org">http://metagenomics.nmpdr.org</a>	Glass <i>et al.</i> (2010)
	IMG-M (Integrated Microbial Genomics/ Metagenomics)		<a href="http://img.jgi.doe.gov">http://img.jgi.doe.gov</a>	Markowitz <i>et al.</i> (2012), Markowitz <i>et al.</i> (2014)
	MetaRep (METAgenomics REPortS)	High-performance comparative metagenomics	<a href="http://www.jcvi.org/metarep/">http://www.jcvi.org/metarep/</a> ; <a href="http://www.jcvi.org/hmp-metarep/">http://www.jcvi.org/hmp-metarep/</a>	Goll <i>et al.</i> (2010), Goll <i>et al.</i> (2012)
	CAMERA (Community cyberinfrastructure from Advanced Microbial Ecology Research and Analysis)	Data analysis pipeline, single platform	<a href="http://camera.calit2.net">http://camera.calit2.net</a>	Sun <i>et al.</i> (2011b)
	MEGAN	Metagenome analysis software	<a href="http://www-ab.informatik.uni-tuebingen.de/software/megan">http://www-ab.informatik.uni-tuebingen.de/software/megan</a>	Huson <i>et al.</i> (2007), Huson and Weber (2013), Mitra <i>et al.</i> (2011)
	DIYA	Bacterial annotation pipeline	<a href="https://github.com/bioteam/DIYA">https://github.com/bioteam/DIYA</a>	Stewart <i>et al.</i> (2009)
	RATT	Transfer annotation from reference genome onto assembly	<a href="http://ratt.sourceforge.net/">http://ratt.sourceforge.net/</a> (now, part of PAGIT: <a href="http://www.sanger.ac.uk/resources/software/pagit/">http://www.sanger.ac.uk/resources/software/pagit/</a> )	Otto <i>et al.</i> (2011)
	VMGAP	Virus-specific annotation pipeline		Lorenzi <i>et al.</i> (2011)
	CloVR	Virtual machine, automated sequence analysis from desktop, cloud computing.	<a href="http://clovr.org">http://clovr.org</a>	Angiuoli <i>et al.</i> (2011), White <i>et al.</i> (2013)
	Galaxy	Web-based data analysis pipeline	<a href="https://usegalaxy.org/">https://usegalaxy.org/</a>	Blankenberg <i>et al.</i> (2010)
Assembly tools	HUMANn	Direct read alignment against protein DB, without prior assembly	<a href="http://huttenhower.sph.harvard.edu/humann">http://huttenhower.sph.harvard.edu/humann</a>	Abubucker <i>et al.</i> (2012)
	Ergatis	Genome annotation and comparative analysis	<a href="http://ergatis.sourceforge.net/index.html">http://ergatis.sourceforge.net/index.html</a>	Hemmerich <i>et al.</i> (2010), Orvis <i>et al.</i> (2010b)
	MetaPathways	Direct read alignment against protein DB, without prior assembly	<a href="http://hallam.microbiology.ubc.ca/MetaPathways/">http://hallam.microbiology.ubc.ca/MetaPathways/</a>	Konwar <i>et al.</i> (2013)
	RaY	De novo metagenome assembly and profiling	<a href="http://denovoassembler.sourceforge.net/">http://denovoassembler.sourceforge.net/</a>	Boisvert <i>et al.</i> (2012)
	Velvet	De novo assembly, short read alignment, Kmer DeBruijn graph traversal-based method	<a href="http://www.ebi.ac.uk/~zerbino/velvet/">http://www.ebi.ac.uk/~zerbino/velvet/</a>	Namiki <i>et al.</i> (2012), Powell and Seemann (2013), Zerbino (2010), Zerbino <i>et al.</i> (2009)
	SOAPdenovo	Short read assembly, Kmer DeBruijn graph traversal-based method	<a href="http://soap.genomics.org.cn/soapdenovo.html">http://soap.genomics.org.cn/soapdenovo.html</a>	Luo <i>et al.</i> (2012)
	Newbler	De novo assembler, designed for 454 platform	<a href="http://454.com/products/analysis-software/index.asp">http://454.com/products/analysis-software/index.asp</a>	Miller <i>et al.</i> (2010)
	ABYSS	Kmer DeBruijn graph traversal-based method	<a href="http://www.bcgsc.ca/platform/bioinfo/software/abyss">http://www.bcgsc.ca/platform/bioinfo/software/abyss</a>	Simpson <i>et al.</i> (2009)
	ALLPATHs	Kmer DeBruijn graph traversal-based method	<a href="http://www.broadinstitute.org/software/allpaths-lg/blog/">http://www.broadinstitute.org/software/allpaths-lg/blog/</a>	Butler <i>et al.</i> (2008), Maccallum <i>et al.</i> (2009)
	Genovo	Generative probabilistic model of read generation from environmental samples	<a href="http://cs.stanford.edu/group/genovo/">http://cs.stanford.edu/group/genovo/</a>	Laserson <i>et al.</i> (2011)

Table I.1 Continued

Type	Resource	Features	Website	Reference	
	CLCbio	Kmer DeBruijn graph traversal-based method	<a href="http://clcbio.com">http://clcbio.com</a>		
	Meta-IDBA	Kmer DeBruijn graph traversal-based method	<a href="http://i.cs.hku.hk/~alse/hkubrg/projects/metaidba/">http://i.cs.hku.hk/~alse/hkubrg/projects/metaidba/</a>	Peng <i>et al.</i> (2011)	
	MetaVelvet	Kmer DeBruijn graph traversal-based method	<a href="http://metavelvet.dna.bio.keio.ac.jp/">http://metavelvet.dna.bio.keio.ac.jp/</a>	Namiki <i>et al.</i> (2012)	
	SMASHCommunity	Assembly and gene calling, data exploration, visualization	<a href="http://www.bork.embl.de/software/smash/">http://www.bork.embl.de/software/smash/</a>	Arumugam <i>et al.</i> (2010)	
Mapping/ Alignment tools	BWA	Mapping low-divergent sequences, based on Burrows-Wheeler aligners	<a href="http://bio-bwa.sourceforge.net/">http://bio-bwa.sourceforge.net/</a>	Li and Durbin (2009)	
	Bowtie	Memory-efficient short read aligner, based on Burrows-Wheeler index	<a href="http://bowtie-bio.sourceforge.net/index.shtml">http://bowtie-bio.sourceforge.net/index.shtml</a>	Langmead <i>et al.</i> (2009)	
	Novoalign	Single-ended and paired-end reads, Illumina GA platform, Needleman-Wunsch algorithm	<a href="http://www.novocraft.com/main/index.php">http://www.novocraft.com/main/index.php</a>		
	SOAP	Alignment of short oligonucleotides	<a href="http://soap.genomics.org.cn/soap1/">http://soap.genomics.org.cn/soap1/</a>	Li <i>et al.</i> (2008), Li <i>et al.</i> (2009)	
	MrFAST	Mapping NGS reads, prediction of copy-number variation of duplicated segments and genes	<a href="http://mrfast.sourceforge.net/">http://mrfast.sourceforge.net/</a>	Alkan <i>et al.</i> (2009)	
	CloudBurst	Parallel read-mapping algorithm, SNP discovery, genotyping	<a href="http://sourceforge.net/projects/cloudburst-bio/">http://sourceforge.net/projects/cloudburst-bio/</a>	Nguyen <i>et al.</i> (2011), Schatz (2009)	
	BFAST	Mapping of short reads to reference genomes	<a href="http://sourceforge.net/projects/bfast/">http://sourceforge.net/projects/bfast/</a>	Homer <i>et al.</i> (2009)	
	MUMer	Rapid genome alignment	<a href="http://mummer.sourceforge.net/">http://mummer.sourceforge.net/</a>	Kurtz <i>et al.</i> (2004)	
		BLAST (Basic Local Alignment Search Tool)	Local similarity between sequences	<a href="http://blast.ncbi.nlm.nih.gov/Blast.cgi">http://blast.ncbi.nlm.nih.gov/Blast.cgi</a>	
		MAQ (Mapping and Assembly with Quality)	Based on Burrows-Wheeler aligners	<a href="http://maq.sourceforge.net/">http://maq.sourceforge.net/</a>	Kumps <i>et al.</i> (2010)
Reference DB for functional metagenomics	KEGG (Kyoto Encyclopaedia of Genes and Genomes)	Integrated database (16 main DB), broadly categorized systems, genomic, chemical, health information	<a href="http://www.genome.jp/kegg/">http://www.genome.jp/kegg/</a>		
	SEED	Comparative genomics environment, curation of genomic data, by annotator across many genes	<a href="http://www.theseed.org">http://www.theseed.org</a>		
	CAZy (Carbohydrate Active enZyme database)	Genomic, structural, and biochemical information on CAZymes	<a href="http://www.cazy.org/">http://www.cazy.org/</a>		
	PFAM	Collection of protein families using multiple sequence alignments and hidden Markov models	<a href="http://pfam.xfam.org/">http://pfam.xfam.org/</a>		
	Phylofacts	Structural phylogenomic encyclopaedia for protein functional and structural classification	<a href="http://phylogenomics.berkeley.edu/phylofacts/">http://phylogenomics.berkeley.edu/phylofacts/</a>		
	Uniprot	Protein sequence and functional information	<a href="http://www.uniprot.org/">http://www.uniprot.org/</a>		
	Mascot	Search engine that uses mass spectrometry data to identify proteins from primary sequences	<a href="http://www.matrixscience.com/home.html">http://www.matrixscience.com/home.html</a>		
16S based analysis tools	MOTHUR	16S-focused, quality-control, taxonomic profiling, data exploration, statistical analysis, visualization	<a href="http://www.mothur.org/wiki/Main_Page">http://www.mothur.org/wiki/Main_Page</a>	Schloss <i>et al.</i> (2009)	
	QIIME (Quantitative Insights Into Microbial Ecology)		<a href="http://qiime.org/">http://qiime.org/</a>	Caporaso <i>et al.</i> (2010), Kuczynski <i>et al.</i> (2011), Navas-Molina <i>et al.</i> (2013)	
	VAMPS (Visualization and Analysis of Microbial Populations)		<a href="http://vamps.mbl.edu/">http://vamps.mbl.edu/</a>	Huse <i>et al.</i> (2014)	

**Table I.1** Continued

Type	Resource	Features	Website	Reference
Data exploration, statistical analysis and visualization tools	bioBakery	Metagenome-focused, taxonomic and functional profiling, data exploration, statistical analysis, visualization	<a href="http://huttenhower.sph.harvard.edu/biobakery">http://huttenhower.sph.harvard.edu/biobakery</a>	
	MetaPhlAn	Clade-specific marker genes, assign reads	<a href="http://huttenhower.sph.harvard.edu/metaphlan">http://huttenhower.sph.harvard.edu/metaphlan</a>	Segata <i>et al.</i> (2012)
	PhymmBL	Classification method using interpolated Markov models	<a href="http://www.cbcb.umd.edu/software/phymm/">http://www.cbcb.umd.edu/software/phymm/</a>	Brady and Salzberg (2009, 2011)
	STAMP (Statistical Analysis of Metagenomic Profiles)	Data exploration, quality control, taxonomic profiling, data exploration, statistical analysis, visualization	<a href="http://kiwi.cs.dal.ca/Software/STAMP">http://kiwi.cs.dal.ca/Software/STAMP</a>	Parks and Beiko (2010)
	LEfSe		<a href="http://huttenhower.sph.harvard.edu/galaxy/">http://huttenhower.sph.harvard.edu/galaxy/</a>	Segata <i>et al.</i> (2011)
	MaAsLin		<a href="http://huttenhower.sph.harvard.edu/galaxy/">http://huttenhower.sph.harvard.edu/galaxy/</a>	
	MetaStats		<a href="http://metastats.cbcb.umd.edu/">http://metastats.cbcb.umd.edu/</a>	Foster (2003)
	PICRUSt	Determination of virtual metagenome by using 16S data set	<a href="http://huttenhower.sph.harvard.edu/galaxy/">http://huttenhower.sph.harvard.edu/galaxy/</a>	
	microPITA	Targeted selection of samples	<a href="http://huttenhower.sph.harvard.edu/galaxy/">http://huttenhower.sph.harvard.edu/galaxy/</a>	Tickle <i>et al.</i> (2013)

## Chapter 18

- Prebiotics:
  - <http://www.prebiotin.com/science/>
- Necrotizing enterocolitis:
  - <http://www.nlm.nih.gov/medlineplus/ency/article/001148.htm>
- Diabetes:
  - <http://www.diabetes.co.uk/news/2013/Feb/prebiotic-supplement-linked-to-reduced-risk-of-type-2-diabetes-96394547.html>
  - <http://lowcarbdiets.about.com/od/nutrition/a/oligosaccharide.htm>
- Obesity:
  - <http://www.optibacprobiotics.co.uk/blog/2013/01/could-prebiotics-help-to-tackle-obesity>
- Cosmetic:
  - <http://www.henkel.com/press/2005-12028-prebiotic-cosmetics-restore-natural-bacterial-balance-5868.htm>
- Allergy:
  - <http://www.medscape.com/viewarticle/804455>
  - <http://www.cochrane.org/podcasts/issue-1-3-january-march-2013/prebiotics-infants-prevention-allergy>
- Vaginal health:
  - <http://vhessentials.com/products-prebiotic-suppositories.php>
- Aquaculture:
  - <http://www.thefishsite.com/articles/1280/probiotics-in-aquaculture-do-they-work>
- [http://www.prebiotic.ca/prebiotic\\_fibre.html](http://www.prebiotic.ca/prebiotic_fibre.html)
- <http://www.fda.gov/default.htm>
- Inulin:
  - <http://www.prebiotic.ca/inulin.html>
- Fructooligosaccharides (FOS):
  - <http://www.vrg.org/blog/2012/10/22/oligofructose-and-fructooligosaccharides-fos-derived-mostly-from-chicory-root-or-cane-sugar/>
  - [http://bodyecology.com/articles/understanding\\_fos.php](http://bodyecology.com/articles/understanding_fos.php)
- Lactulose:
  - <http://suppversity.blogspot.com.br/2014/01/supplement-review-lactulose-isomerized.html>
- Galactooligosaccharides (GOS):
  - <http://www.fortitechpremixes.com/research/galactooligosaccharides-increase-calcium-absorption-in-young-girls/>
  - <http://www.healthsnap.ca/blog/what-does-that-mean-galactooligosaccharides.html>
- Resistant starch (RS):
  - <http://www.precisionnutrition.com/all-about-resistant-starch>
  - <http://digestivehealthinstitute.org/2013/05/10/resistant-starch-friend-or-foe/>
- Soybean oligosaccharides:
  - <http://www.whfoods.com/genpage.php?tname=foodspice&dbid=110>
- Xylooligosaccharides (XOS):
  - <http://www.healthyfellow.com/1199/a-new-prebiotic-ingredient/>
- Isomaltooligosaccharides (IMO):
  - <http://blog.questnutrition.com/what-is-isomaltooligosaccharide/>

## Chapter 19

- Prebiotics:
  - <http://www.isapp.net/>

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**Chapter 20**

- <http://www.cazy.org/Genomes.html> is a database providing genomic and enzyme information on the carbohydrate active enzymes of all organisms
- <http://www.phenol-explorer.eu/Phenol-Explorer> is a comprehensive database on polyphenol content in foods

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**Chapter 21**

- HealthGrain:
  - <https://www.healthgrain.org/>
- Fibebiotics:
  - <http://www.fibebiotics.eu/>
- Dietary Guidelines:
  - [www.DietaryGuidelines.gov](http://www.DietaryGuidelines.gov)
- Selected products:
  - BioBran (Arabinoxylan): <http://daiwa-pharm.com/english/product/biobran.html>
  - Oat bran (beta-glucan): <http://www.med.nyu.edu/content?ChunkIID=104429>

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**Chapter 22****Fibres**

- Fibres definition:
  - [http://www.codexalimentarius.net/download/report/710/al32\\_26e.pdf](http://www.codexalimentarius.net/download/report/710/al32_26e.pdf);
  - <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:285:0009:0012:en:pdf>

**Polyphenols**

- Comprehensive database on polyphenol content in foods, including comprehensive data on polyphenol metabolism:
  - <http://www.phenol-explorer.eu/>

**Human milk oligosaccharides**

- David Mill's lab with the description of the human milk project:
  - <http://fgp.ucdavis.edu/prog/fg/proj/mo>
- Bod's lab dedicated to research on human milk oligosaccharides:
  - <http://www.bodelab.com/bode-lab/Welcome.html>
- Company sites (HMO suppliers):
  - [http://www.inbiose.com/products\\_hmo.htmlxf](http://www.inbiose.com/products_hmo.htmlxf)
  - [http://www.glycom.com/product\\_samples.asp](http://www.glycom.com/product_samples.asp)
  - [http://www.elicityl-oligotech.com/client/document/elicityl---oligotech---human---mammalian-milk-oligosaccharides-hmos\\_24.pdf](http://www.elicityl-oligotech.com/client/document/elicityl---oligotech---human---mammalian-milk-oligosaccharides-hmos_24.pdf)
  - [http://www.carbosynth.com/carbosynth/website.nsf/\(w-productdisplay\)/CA9C3737BB8CEA8480256A6B00359924](http://www.carbosynth.com/carbosynth/website.nsf/(w-productdisplay)/CA9C3737BB8CEA8480256A6B00359924)
  - [http://www.jennewein-biotech.de/en\\_food.php](http://www.jennewein-biotech.de/en_food.php)

**Polyols**

- European Association of Polyol producers website monitoring the regulatory development surrounding polyol and providing scientific based information:
  - <http://www.polyols-eu.com/index.php>

**Peptides as novel prebiotics**

- Examples of patents mentioned peptides as potential prebiotics?:
  - <https://www.google.com/patents/EP1355541A1?cl=en&dq=glycomacropeptide+prebiotic&hl=en&sa=X&ei=kZbHU86BDYLOygPvroJQ&ved=0CDMQ6AEwAw>
  - <https://www.google.com/patents/EP1228707A1?cl=en&dq=glycomacropeptide+prebiotic&hl=en&sa=X&ei=kZbHU86BDYLOygPvroJQ&ved=0CCwQ6AEwAg>

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**Chapter 23**

- FSTA®:
  - an intelligence service constantly monitoring developments in the areas of food science, food technology and nutrition
  - <http://www.foodsciencecentral.com/>
- IFIC:
  - International Food Information Council Foundation
  - dedicated to the mission of effectively communicating science-based information on health, nutrition and food safety for the public good
  - <http://www.foodinsight.org/>
- FAO/WHO views on probiotics:
  - [http://www.who.int/foodsafety/publications/fs\\_management/en/probiotics.pdf](http://www.who.int/foodsafety/publications/fs_management/en/probiotics.pdf)
  - [http://www.who.int/foodsafety/fs\\_management/en/probiotic\\_guidelines.pdf?ua=1](http://www.who.int/foodsafety/fs_management/en/probiotic_guidelines.pdf?ua=1)
- International Life Sciences Institute (ILSI) task-force on probiotics:
  - [http://www.ilsilife.org/Europe/Pages/TF\\_Probiotics.aspx](http://www.ilsilife.org/Europe/Pages/TF_Probiotics.aspx)
- ILSI task-force on prebiotics:
  - [http://www.ilsilife.org/Europe/Pages/TF\\_Prebiotics.aspx](http://www.ilsilife.org/Europe/Pages/TF_Prebiotics.aspx)
- ISAPP:
  - International Scientific Association for Probiotics and Prebiotics
  - <http://www.isapp.net/>
- American Gut:
  - World's largest open-source science project to understand the microbial diversity of the Human Gut. Learn which microbes live in your gut, skin & mouth
  - <http://humanfoodproject.com/americangut/>

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**Chapter 24**

- Gut microbiota expert information exchange
  - <http://www.gutmicrobiotaforhealth.com/>
- Newly published obesity-related research
  - <http://www.obesityandenergetics.org/>

- Blogs written by prominent obesity prevention and management researchers:
  - Dr. Sharma's Obesity Notes (<http://www.drsharma.ca/>)
  - <http://www.weightymatters.ca/>
  - <http://www.davidkatzmd.com/>
- Video: Friends with Benefits: The Human Microbiome
  - <http://www.youtube.com/watch?v=GAF-AbJJpfM>
- Allergies:
  - <http://www.sciencedaily.com/releases/2013/03/130328075716.htm>

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## Chapter 25

The MetaHIT (Metagenomics of the Human Intestinal Tract) is an EU-financed project aiming at establishing associations between the genes of the human intestinal microbiota and our health and disease: <http://www.metahit.eu>

The International Human Microbiome Standards (IHMS) project is an EU-financed project which seeks to coordinate development of standard operating procedures (SOPs) and protocols that will optimize data comparisons in the human microbiome field: <http://www.microbiome-standards.org>

The European Network for Gastrointestinal Health Research (ENGIHR) is a European Science Foundation Research Networking Programme (RNP) which promotes interactions between researchers interested in gut health research in Europe: <http://www.engihr.eu>

This consumer-oriented webpage provides a wide range of information about gut and health, including the gut-brain -axis and pre- and probiotics: <http://www.gutandbowel.com>

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## Chapter 26

### Probiotics and their paediatric use

- Research on fundamental and applied aspects of probiotics and prebiotics:
  - <http://www.isapp.net/>
- Children intestinal disease:
  - <http://www.webmd.com/children/news/20101128/children-may-benefit-from-probiotics-prebiotics>
- Bifidobacteria:
  - <http://naturaldatabase.therapeuticresearch.com/nd/PrintVersion.aspx?id=891&AspxAutoDetectCookieSupport=1>
- Guidelines for the Evaluation of Probiotics in Food:
  - <ftp://ftp.fao.org/es/esn/food/wgreport2.pdf>
- Regulation for probiotics:
  - <http://ylfa.org/images/file/Workable%20solution%20for%20probiotics-2012.pdf>

### Prebiotics and their paediatric use

- Research on fundamental and applied aspects of probiotics and prebiotics:
  - <http://www.isapp.net/>
- Children intestinal disease:
  - <http://www.webmd.com/children/news/20101128/children-may-benefit-from-probiotics-prebiotics>

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## Chapter 27

Useful web resources related to the management of irritable bowel syndrome:

- <http://onlinelibrary.wiley.com/advanced/search/results>
- <http://www.springer.com/food+science/book/978-0-387-79057-2>
- <http://www.ncbi.nlm.nih.gov/pubmed/?term=probiotic+and+prebiotic>
- <http://scholar.google.co.in/scholar?q=probiotic+and+prebiotic+in+IBS>
- [http://www.worldgastroenterology.org/assets/export/userfiles/Probiotics\\_FINAL\\_20111128.pdf](http://www.worldgastroenterology.org/assets/export/userfiles/Probiotics_FINAL_20111128.pdf)
- [http://www.theromefoundation.org/rome\\_III\\_gastro/](http://www.theromefoundation.org/rome_III_gastro/)
- <http://www.aafp.org/afp/2009/0615/p1108.html>
- [www.sciencedirect.com](http://www.sciencedirect.com)

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## Chapter 28

### Science sites

- The human oral microbiome database:
  - <http://www.homd.org/>

### Company sites

- Biogaia AB:
  - <http://www.biogaia.com>
- Chr Hansen:
  - <http://www.chr-hansen.com>
- Yakult probiotic milk drink:
  - <http://www.yakult.co.jp/english>

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## Chapter 29

### Molecular docking

- Learn more about Molecular docking:
  - [http://www.biomolecular-modeling.com/Software\\_Docking.html](http://www.biomolecular-modeling.com/Software_Docking.html)
- Free docking software:
  - <http://autodock.scripps.edu/>
- Complete docking suite:
  - <http://www.schrodinger.com/Glide>
- Guidelines for evaluation and safety of probiotics in food
  - [http://www.who.int/foodsafety/publications/fs\\_management/probiotics2/en/](http://www.who.int/foodsafety/publications/fs_management/probiotics2/en/)
- More statistical and global brief on cardiovascular diseases:
  - [http://www.who.int/cardiovascular\\_diseases/en/](http://www.who.int/cardiovascular_diseases/en/)



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**Chapter 30****Livestock feed supplements**

- BENEIO:
  - <http://www.beneo.com>
- BiOWiSH Technologies:
  - <http://www.biowishtechologies.com>
- Kemin Industries:
  - <http://www.kemin.com>
- Novus International:
  - <http://www.novusint.com>

**Microbial culture repositories**

- American Type Culture Collection:
  - <http://www.atcc.org>
- Japan Collection of Microorganisms:
  - <http://jcm.brc.riken.jp>

**Animal research resources**

- Federation of Animal Science Societies:
  - <http://www.fass.org>
- Guide for the Care and Use of Agricultural Animals in Research and Teaching:
  - <http://www.fass.org/page.asp?pageID=216>
- European Federation of Animal Science:
  - <http://www.eaap.org>
- Association for Assessment and Accreditation of Laboratory Animal Care International:
  - <http://www.aalac.org>
- Guide for the Care and Use of Laboratory Animals:
  - <http://www.aalac.org/resources/theguide.cfm>

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**Chapter 32**

The International Scientific Association for Probiotics and Prebiotics (ISAPP):

- <http://www.isapp.net/>

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