

One health probiotics



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This issue of *Microbiology Australia* is on the topic of probiotics. The word ‘probiotic’, meaning ‘for life’, is derived from Latin ‘pro’ and Greek ‘bios’. According to the World Health Organization and the Food and Agriculture Organization of the United Nations, probiotics are defined as ‘live microorganisms which when administered in adequate amounts confer a health benefit on the host’¹, while a very similar definition, albeit with the term ‘body’ (i.e. not plant), is used by the US National Institutes of Health: ‘... live microorganisms that are intended to have health benefits when consumed or applied to the body.’². The field of human probiotics is steeped in a long history. Over a century ago, the Nobel laureate (1908) Ilya Ilyich (Élie) Metchnikoff suggested that human health could be enhanced and senility delayed by modifying the gut microbiota with lactic acid bacteria from fermented milk products – he is generally known as ‘the father of probiotics’³. However, reference to human gut benefits from consumption of fermented milk predate Metchnikoff by millennia (e.g. Pliny the Elder) and sacred texts from Christianity and Hinduism mention fermented foods and their benefits⁴. Probiotic research took a major uptick with the advent of next generation DNA sequencing leading to multiple host associated microbiome initiatives including the human microbiome project, which revealed the importance of lactic acid bacteria as part of human microbiomes in different parts of the body⁵.

In this issue of *Microbiology Australia* on probiotics, we present a broad one health coverage of the topic. Several aspects of probiotics for humans including production and regulation are discussed. However, we also go outside the classical human probiotics field to cover application to production animals and plants as well as application to marine native animals.

Fittingly, the first article is on future probiotic foods by Van Ho and Mark Turner (University of Queensland). Although milk is a common probiotic carrier, lactose intolerance makes this unsuitable for all and Ho and Turner explore other carriers like

encapsulation and other foods including juices and vegetables. A multinational group led by Tristan Yusho Huang have written an article on natural skin microbiota members, including *Staphylococcus epidermidis*, which produce short-chain fatty acids that suppress the growth of the pathogen *Staphylococcus aureus*. A great overview of faecal microbiome transplantation (FMT) is given by Holly Sinclair from the Royal Brisbane and Women’s Hospital (RBWH) and Paul Chapman (Queensland Institute of Medical Research Berghofer Medical Research Institute). Treatment of *Clostridioides difficile* infections and other human gut dysbioses are covered. A second FMT article on gastrointestinal illness is presented by Hayley Reed and Jakob Begun from the Mater Research Institute with emphasis on immune homeostasis. The relevance of probiotics in caesarean-born neonates is covered by Hanna Sidjabat (The University of Queensland when this issue was prepared and currently with Griffith University Menzies Health Institute Queensland), her previous students, Adam Irwin (Children’s Health Queensland Hospital and Health Service) and Pieter Koorts (Neonatal Unit at RBWH). The probiotics industry for human consumption is anticipated to reach ~US\$69.3 billion by 2023 as reported by Joe Liu, Brendan Cook and Shaun Roux from Probiotics Australia. They have opened Australia’s only regulation certified probiotics production facility and their article covers the full gamut of the challenges around the commercialisation of probiotics. The article discusses topics from strain selection, mass manufacture, downstream processing, and finally shipping.

The topics in the Probiotics issue then switch focus from humans to the use of probiotics in animals. Dairy cattle are the focus in an article by Divya Krishnan and colleagues mostly from the University of Queensland and including Timothy Olchoway from University of Calgary, Canada. Mammary gland dysbiosis in milk producing cows and calf growth improvements via gastrointestinal tract probiotics are covered. In the pork industry, piglet mortality is a major issue. Although antibiotics were the go-to

strategy, antibiotic resistance and bans on antibiotic use have motivated alternative approaches including probiotics. Nowland and Kirkwood (University of Adelaide) describe FMT as a potential future probiotic strategy for piglets, using the human FMT successes in treating *Clostridioides difficile* infections as a model (and described by Sinclair and Chapman in this issue). The nascent probiotic application in these two production animal fields (cattle and pigs) requires quite some work before efficacy will be proven and broad adoption by practitioners is achieved. Probiotics in freshwater farmed fish are covered by an international collaboration of Luisa Marcela Villamil-Diaz (Universidad de La Sabana, Colombia) and colleagues from Australia and USA. Growth promotion, pathogen inhibition and stress tolerance are among benefits that could be conferred to fish by probiotics. The article also covers probiotic application to the animals. Although not covered in this *Microbiology Australia* issue, extensive use of probiotics in broiler chicken production has been of longer application and quite efficacious compared to other food-production animals⁶, and a recent paper⁷ concludes excellent prospects for the application of probiotics and other microbiome-directed therapies in taxa ranging from horses to salamanders to bees.

We have one article on probiotics in plants by Rob Walker and colleagues from the University of Melbourne. One of the most classical 'probiotics' in plants is the use of *Rhizobium* inoculants⁸. Rob and his co-authors discuss many plant-related probiotic topics and they are anticipating a good future for this industry. Last, Australia has the world's largest coral reef system stretching over 2300 km and seen as the world's biggest single structure made by living organisms. Although coral reefs provide critical ecosystem services and substantial personal income, they are globally suffering from one substantial issue called coral bleaching. One novel way to preserve the reefs of the world is to assist them by using introduced microbes which have beneficial properties for the corals. This topic is covered by Linda Blackall and her colleagues from the University of Melbourne.

Not all topics in the field of probiotics are covered in this *Microbiology Australia* issue. The term pharmacomicrobiomics was introduced in 2010 to investigate the interplay of microbiome, drug response and disposition (absorption, distribution, metabolism and excretion)⁹. This model will potentially contribute to the efficacy of biotherapy including therapy with probiotics. There are many recent initiatives in Australia on microbiome research as it relates to gut and environmental health – these are driven by research institutions and commercial companies alike. Enthusiastic researchers, clinicians and academics resonate with the high hopes of probiotics and microbiome research. The probiotics space will be a busy one into the future and this *Microbiology Australia* issue encapsulates some of the recognised areas while also covering less familiar ground.

Happy reading!

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Biographies

Dr Hanna E Sidjabat is a molecular microbiologist with a strong industry link in translating her probiotic research to manufacturing. In addition to her probiotic expertise, she has a solid background in antibiotic resistance mechanisms including genome and proteome due to 15 years of research experience. She has strong research focus in the bacterial genome, proteome of pathogens and probiotics. To date, Dr Sidjabat has published 87 peer-reviewed articles in international journals. Dr Sidjabat has supervised and mentored 35 PhD students, Postdoctoral Research Fellows, Master and Honours students, Microbiology Registrars, local and international Infectious Diseases Visiting Academics following the completion of her PhD in 2007.

Professor Linda I. Blackall is an environmental microbial ecologist, who has studied many different complex microbial communities ranging from host associated through to free living in numerous environments. Her research has covered mammalian microbiomes of marsupials, humans, ruminants and horses; and the microbiota of non-mammals including corals and sponges. Environmental microbiomes explored in Linda's research span wastewater treatment (aerobic and anaerobic), solid waste digestion (landfill and composting), bioelectric systems and microbiologically influenced corrosion. The numerous methods she develops and employs in her research allow elucidation of microbial complexity and function in these diverse biomes.