



Why our Guts Love Wholegrains!

Dr Tim Crowe, AdvAPD

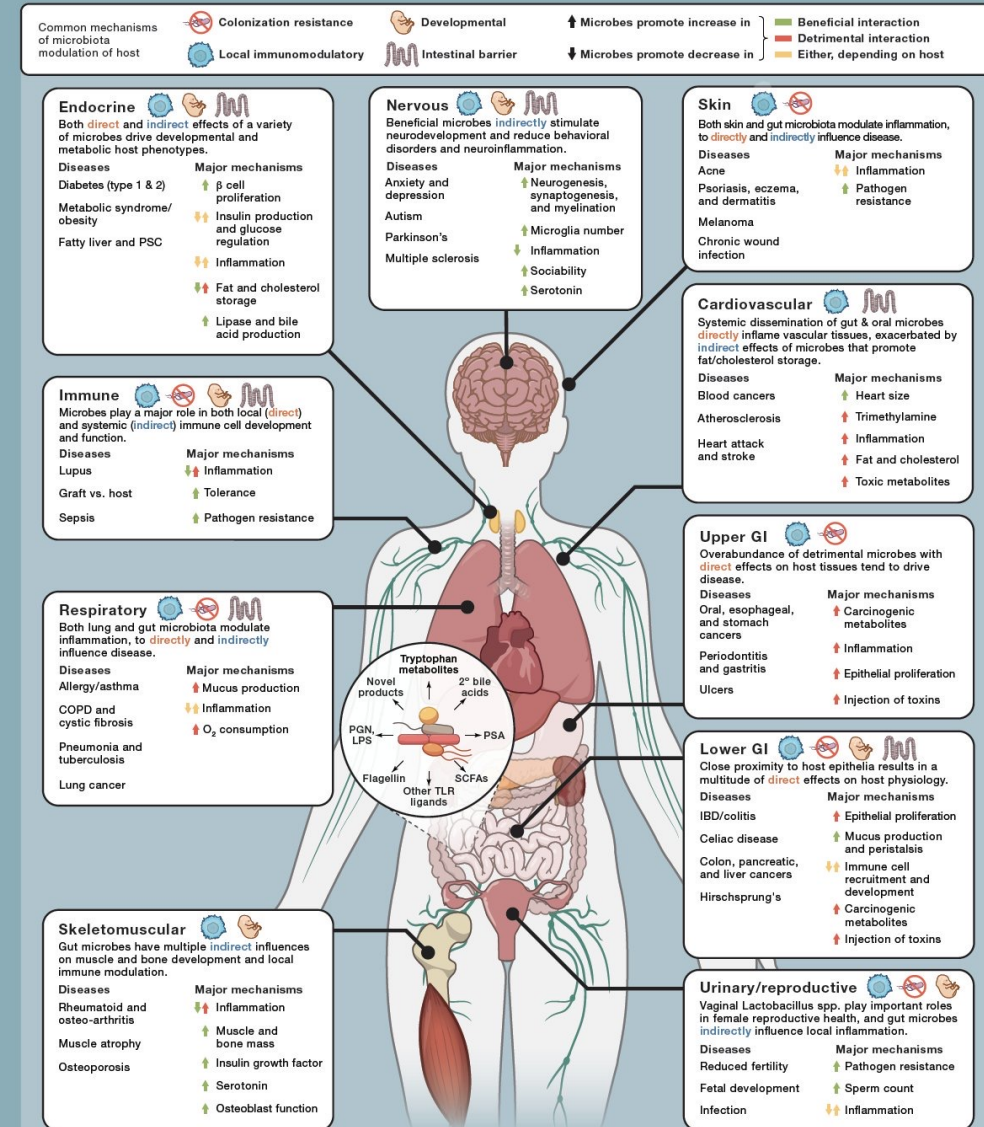
This is why gut health is the hottest of hot topics



SnapShot: Microbiota effects on host physiology

Cell

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University of Utah School of Medicine, Salt Lake City, UT 84112, USA



What is fibre?

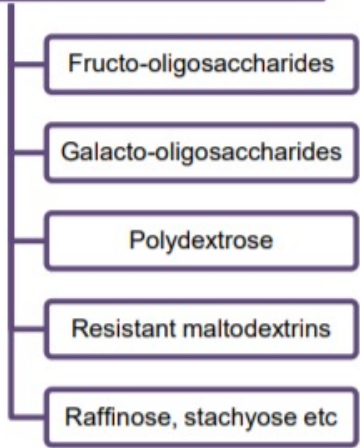
The fraction of the edible part of plants or their extracts (or synthetic analogues) that are resistant to digestion and absorption in the small intestine, usually with complete or partial fermentation in the large intestine

Promotes one or more of the following beneficial physiological effects:

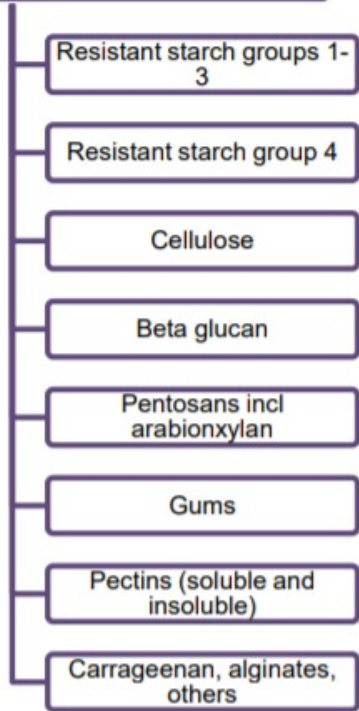
- Laxation
- Reduction in blood cholesterol
- Modulation of blood glucose

Includes oligosaccharides, polysaccharides and lignins

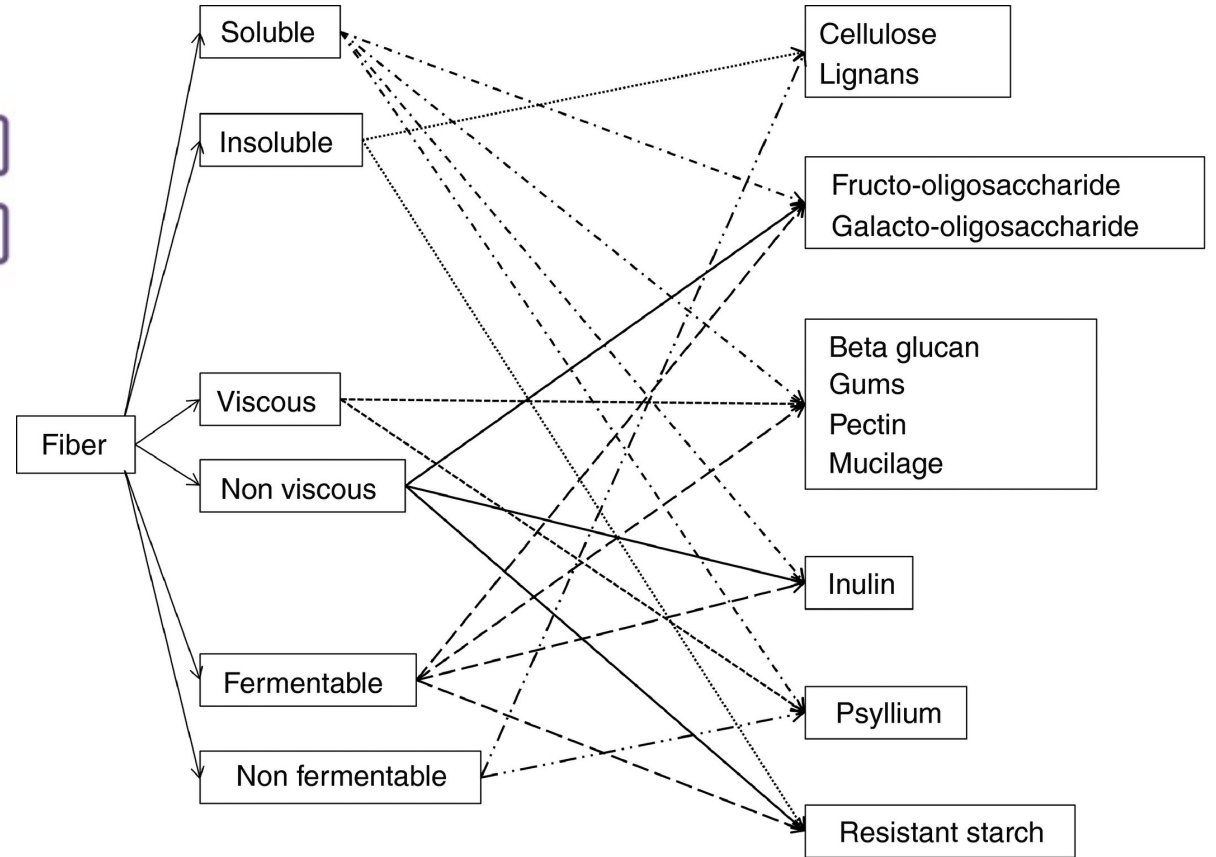
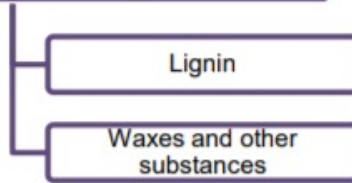
Oligosaccharides, DP3-9



Polysaccharides DP>9



Non-carbohydrate fibres



Westenbrink S et al. *Food Chem* 2013;140:562-7

O'Grady J et al. *Aliment Pharmacol Ther* 2019;49:505-15

Fibre subtype	Structure	Source	Metabolic effect
Cellulose	Linear chains of glucose units with beta-1, 4 glucosidic linkage	Cereals, legumes, nuts	Increases stool bulk and stimulates peristalsis
Hemicellulose	As cellulose with xylose, galactose, mannose and arabinose sugar branches	Cereals, cell walls of fruits, vegetables	Varies with source; mix of insoluble, soluble and viscous properties
Lignan	Complex polymer of aromatic alcohols. Not a polysaccharide	Cereals, plant cell walls	Increases stool bulk and stimulates peristalsis
Gums	Mannose backbone with galactose side chains	Legumes, nuts	Cholesterol and glucose lowering effects, slow digestion and absorption, Fermentation by microbiota
Pectin	Polygalacturonic acid, D-galacturonic acid unit backbone, substituted with arabinans, galactin, arabinogalactin side chains	Fruit peel, legumes, beetroot	Cholesterol and glucose lowering effects, Slow digestion and absorption, Fermentation by microbiota
Beta glucan	Beta-D glucose linear backbone with 1-3 beta glycosidic linkage	Cereals and grains, yeasts, fungi and bacteria	Cholesterol and glucose lowering effects, Fermentation by microbiota
Inulin	Beta 1-2-fructan residue backbone, often glucosyl units as chain terminating moieties	Chicory root, onion, cereals	Lower triglyceride concentration, Fermentation by microbiota
Psyllium	Heteroxylan with 1:4, 1:3 linkage backbone, side chains of arabinose, xylose, galactose and rhamnose	<i>Plantago Ovata</i>	Cholesterol and glucose lowering, Stool forming effects
Oligosaccharides	Beta- fructo- oligosaccharides (FOS) Alpha and beta- galactooligosaccharides (GOS)	Polymers derived from polysaccharides by hydrolysis	Fermentation by microbiota
Resistant starch (RS1-5)	Alpha-1,4-D-glucan links	Cereals, legumes, fruits	Cholesterol and glucose lowering, Fermentation by microbiota

The health benefits

Effect	Health Benefit
Metabolic	Improved insulin sensitivity (mainly insoluble fibres), reduced risk of developing T2D (mainly insoluble cereal fibres and whole grains) Improved glycaemic status and lipid profiles (mainly soluble fibres), reduced body weight and abdominal adiposity
Gut microflora	Gut microbial viability and diversity, metabolites from gut microflora (including SCFAs)
Cardiovascular	Chronic inflammation, cardiovascular risk, mortality
Depression	Chronic inflammation, gut microbiota
Gastrointestinal Localised	Colonic health and integrity, colonic motility, colorectal carcinoma

SCFAs = Short Chain Fatty Acids; T2D = Type 2 Diabetes Mellitus.

Prebiotic fibre is like fertiliser for
your gut microbiota

And what defines prebiotic fibre
continues to broaden as too the
health links being made



Today's definition of a prebiotic

Open Access | Published: 14 June 2017

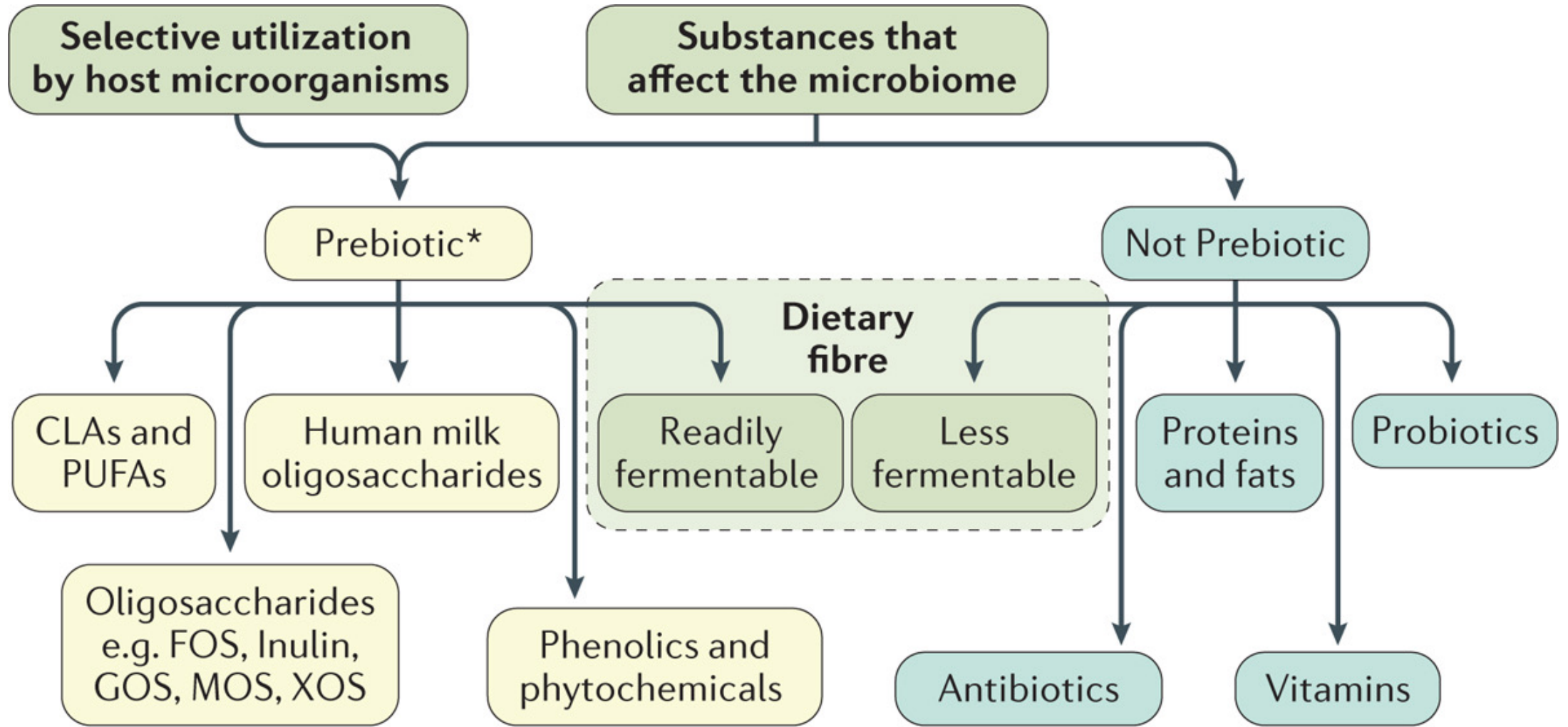
Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics

Glenn R. Gibson , Robert Hutkins, Mary Ellen Sanders, Susan L. Prescott, Raylene A. Reimer, Seppo J. Salminen, Karen Scott, Catherine Stanton, Kelly S. Swanson, Patrice D. Cani, Kristin Verbeke & Gregor Reid

Nature Reviews Gastroenterology & Hepatology **14**, 491–502(2017) | [Cite this article](#)

“A substrate that is selectively utilized by host microorganisms conferring a health benefit.”

The definition expands the concept of prebiotics to possibly include non-carbohydrate substances, applications to body sites other than the GI tract, and diverse categories other than food



Health effects of prebiotics

Include benefits to:

GI tract (inhibition of pathogens, immune stimulation, gut barrier permeability)

Cardiometabolism (↑ insulin sensitivity, blood lipids)

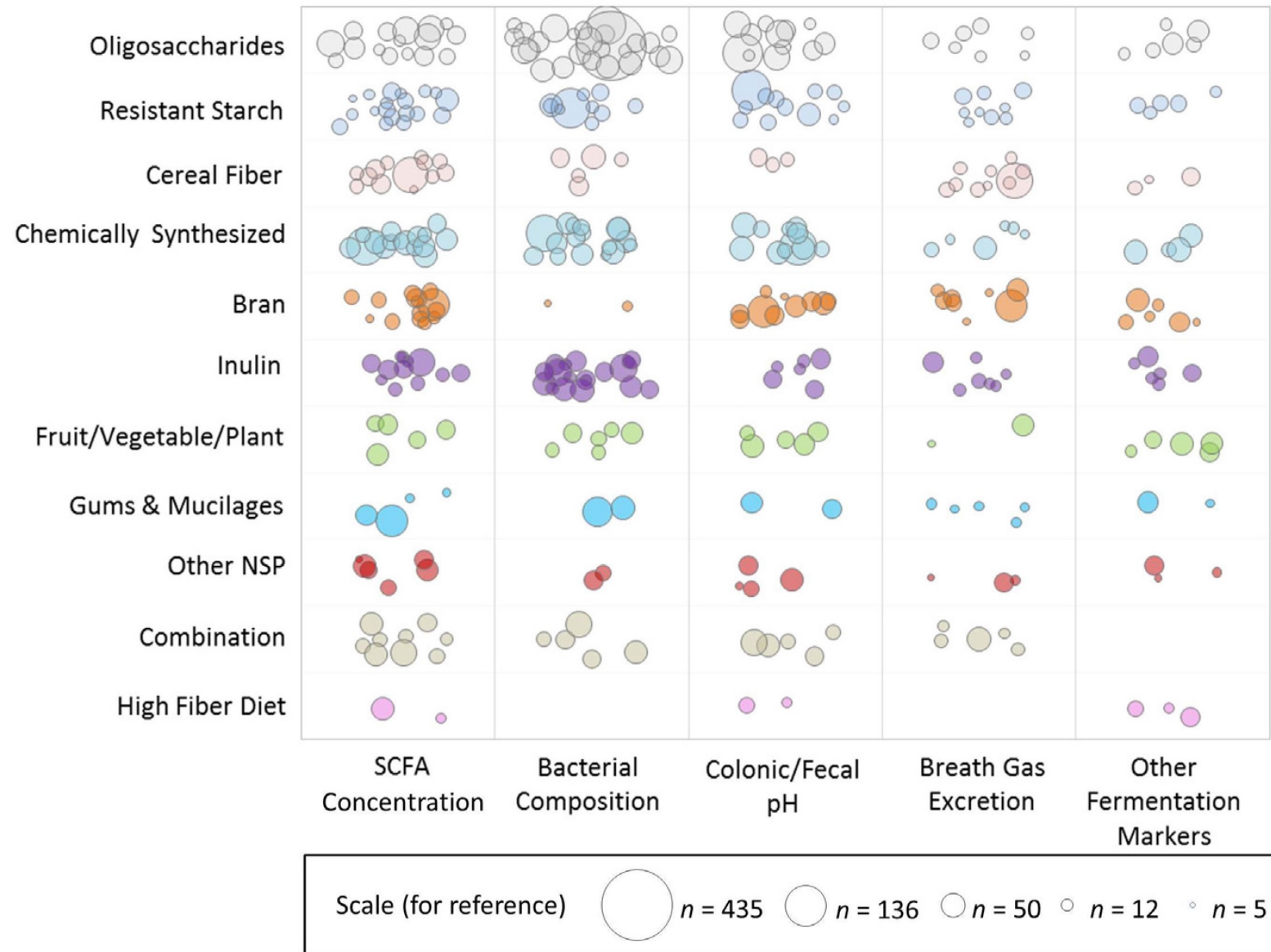
Mental health (metabolites that influence brain function and cognition)

Bone (↑ mineral bioavailability)



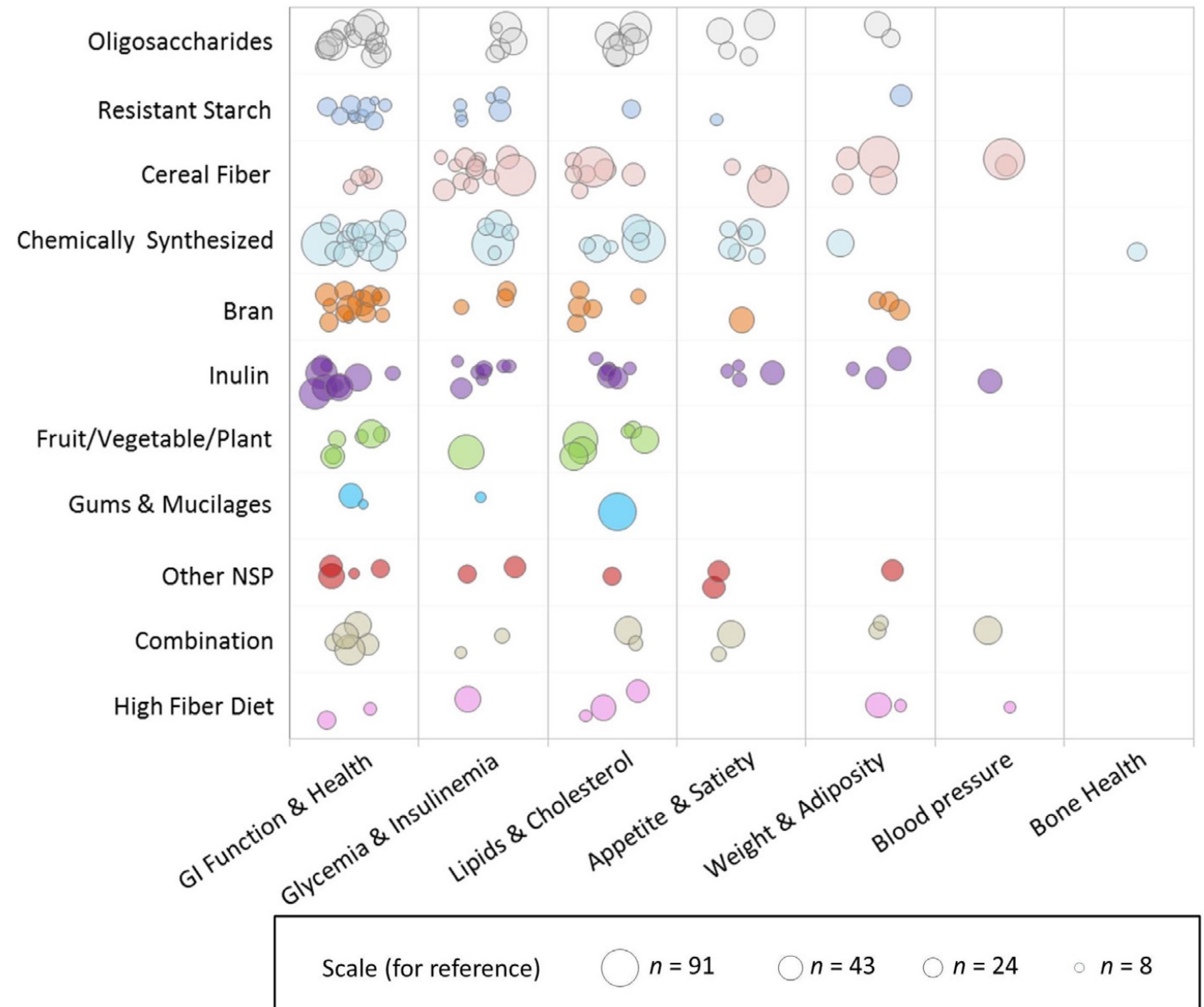
Health effect of prebiotics

Sawicki CM et al.
Nutrients 2017;9:125

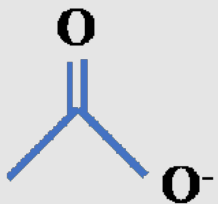


Health effect of prebiotics

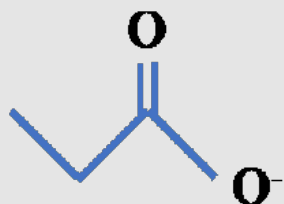
Sawicki CM et al.
Nutrients 2017;9:125



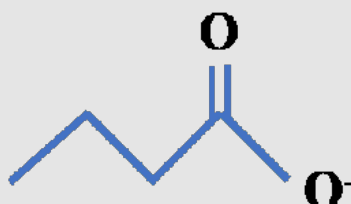
SCFAs (Short-chain fatty acids)



Acetate



Propionate



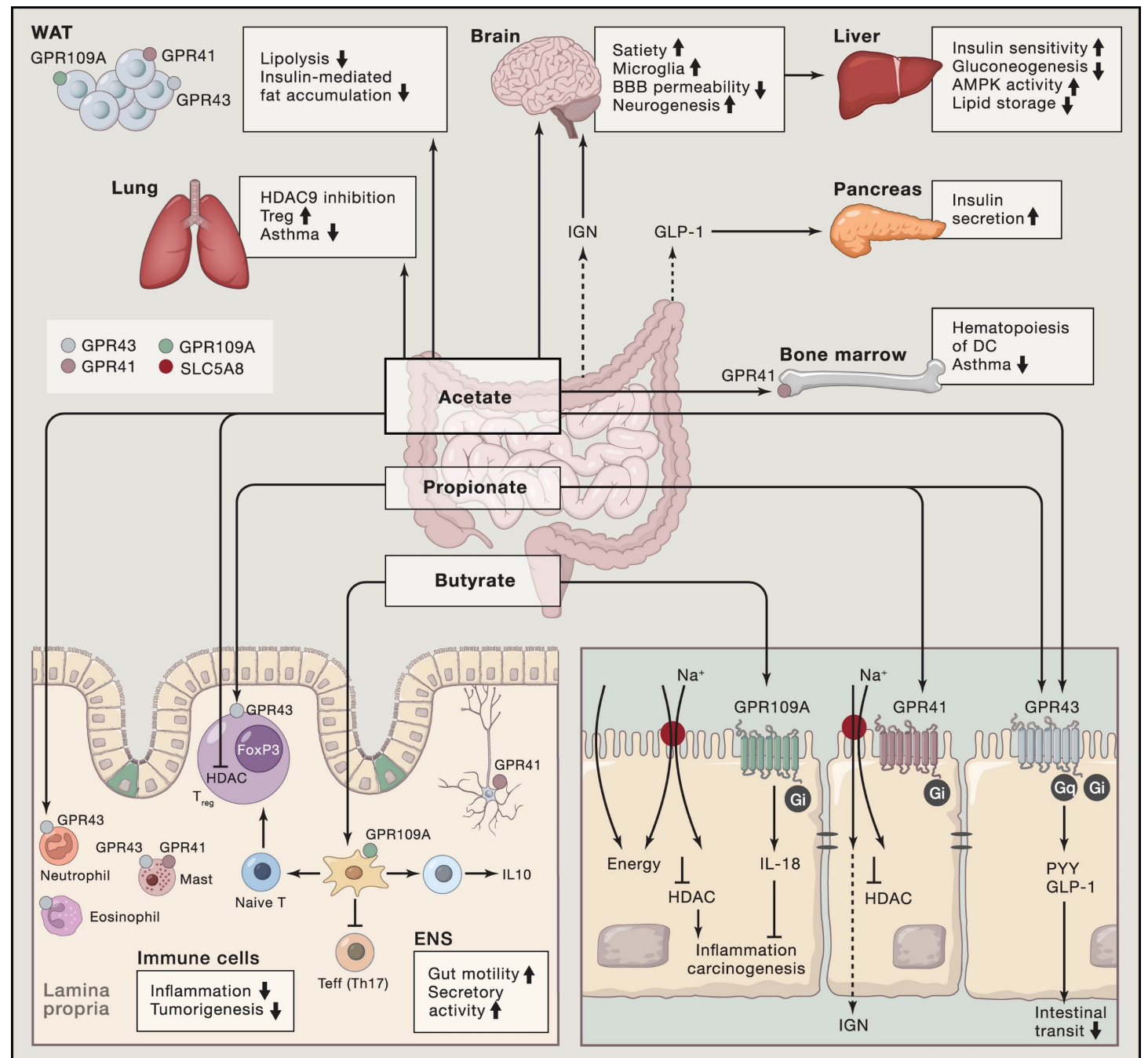
Butyrate

Metabolites of bacterial fermentation of prebiotic fibre and resistant starch

Used as an energy source by enterocytes and for microbial growth (butyrate) or transported into the bloodstream (acetate and propionate)

Modulate aspects of metabolic activity including colonocyte function (nutrient absorption, pH and motility), pathogen proliferation, intestinal barrier integrity, inflammation, blood lipids and appetite

SCFAs – it's complex




Grains and your gut

Grains contain various types of prebiotic fibres that serve as important fuels for the gut microbiota

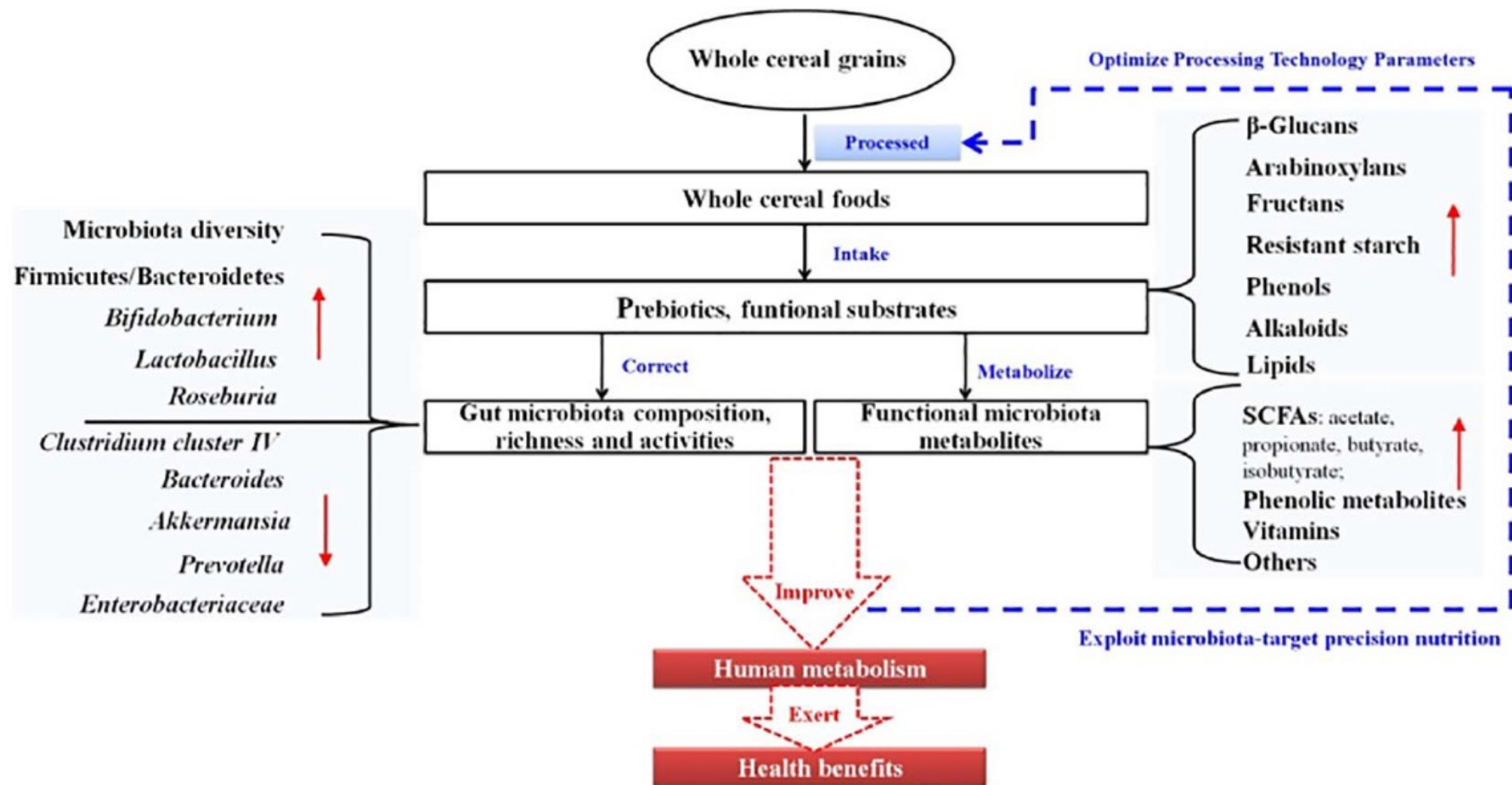
- Arabinoxylans
- Fructans
- Beta-glucan
- Resistant starch



Table 1 Definition and distribution of nondigestible carbohydrates in wheat (% dry matter)

Schematic representation				
Botanical components	Grain	Bran	Aleurone cells and germ	Starchy endosperm
Milling fractions	Wholemeal	Bran flour	Aleurone flour	White flour
Arabinoxylan [2,19**]	Carbohydrates consisting of β (1,4)-linked D-xylopyranosyl residues to which α -L-arabinofuranose units are linked as side chains. Some arabinoses can be substituted with ferulic acid. The degree of substitution refers to the arabinose moieties on the xylose backbone and is further also described as A/X ratio.			
	4–9%	12.7–22.1%	60–70%	1.4–2.8%
Fructan [20–22]	Carbohydrates of fructosyl units with or without one glucosyl unit. Wheat fructans contain both β (1,2) and β (6,2) linkages and have an avDP of up to 19 with a similar molecular weight distribution in the different fractions. Some fructooligosaccharides with an estimated DP of 5–7 in most whole grain whereas fructans in wheat flour have been reported to have a highest DP of 7–8 and ≥ 16 .			
	0.6–2.6%	2.7–3.7%	1.9%	1.5–1.6%
β -Glucan [2,22,23]	Carbohydrates consisting of a linear homopolymer arranged in blocks of consecutive β (1,4)-linked d-glucose residues separated by single β (1,3)-linkages. The chain mainly consists of cellotriosyl (58–72%) and cellotetraosyl (20–34%) units; some cellulosic blocks having more than four residues			
	0.5–1.4%	1.4–1.8%	0.9%	0.3–0.4%
Resistant starch [24]	The starch consists of two main structural components, the amylose, which is essentially a linear polymer in which glucose residues are α -D-(1,4) linked, and amylopectin, which is a larger branched molecule with α -D-(1,4) and α -D-(1,6) linkages. Resistant starch is defined as that fraction of dietary starch, which escapes digestion in the small intestine; it is measured chemically as the difference between total starch obtained from homogenized and chemically treated sample and the digestible starch generated from nonhomogenized food samples by enzyme digestion. It is subdivided into four fractions: RS1, RS2, RS3, and RS4.			
	16.4%	1.1%	0.8% (in germ)	
Cellulose [2,22]	Cellulose is a homopolymer of glucose linked by β -(1,4) linkages only			
	<5%	8–10%	3.9%	0.5–0.6%
Galactooligosaccharides [20,25]	Galactooligosaccharides also called α -galactosides or raffinose family oligosaccharides (RFOs) are soluble low-molecular weight oligosaccharides, such as raffinose (trisaccharide), stachyose (a tetrasaccharide), verbascose (a pentasaccharide) and other oligosaccharides formed by α -(1,6)-galactosides linked to C-6 of the glucose moiety of sucrose.			
	Identified	Not determined	Identified (raffinose: 7.2% in germ)	Not determined

avDP, average degree of polymerization; DP, degree of polymerization.

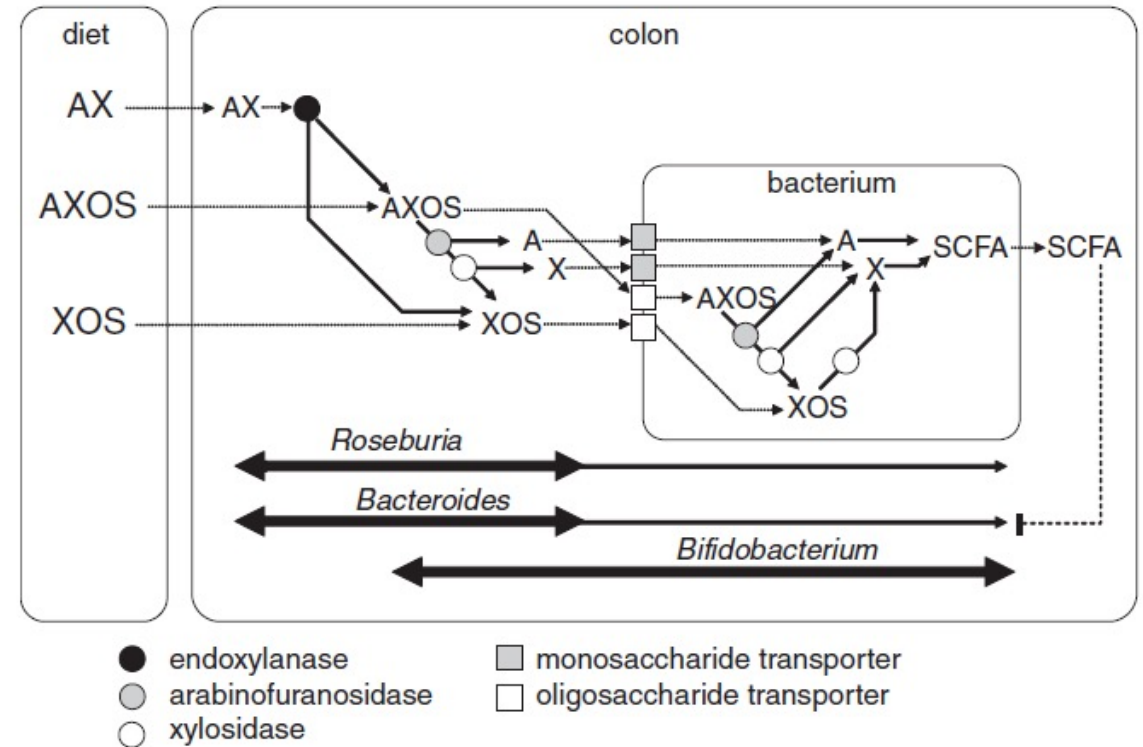


Arabinoxylans

Main non-starch polysaccharide in cereals and component of cell wall

Hydrolysis in the colon leads to arabinoxylan-oligosaccharides (AXOS) and xylo-oligosaccharides (XOS) formation

AXOS and XOS can ↑ *Bifidobacteria*
↑ SCFAs

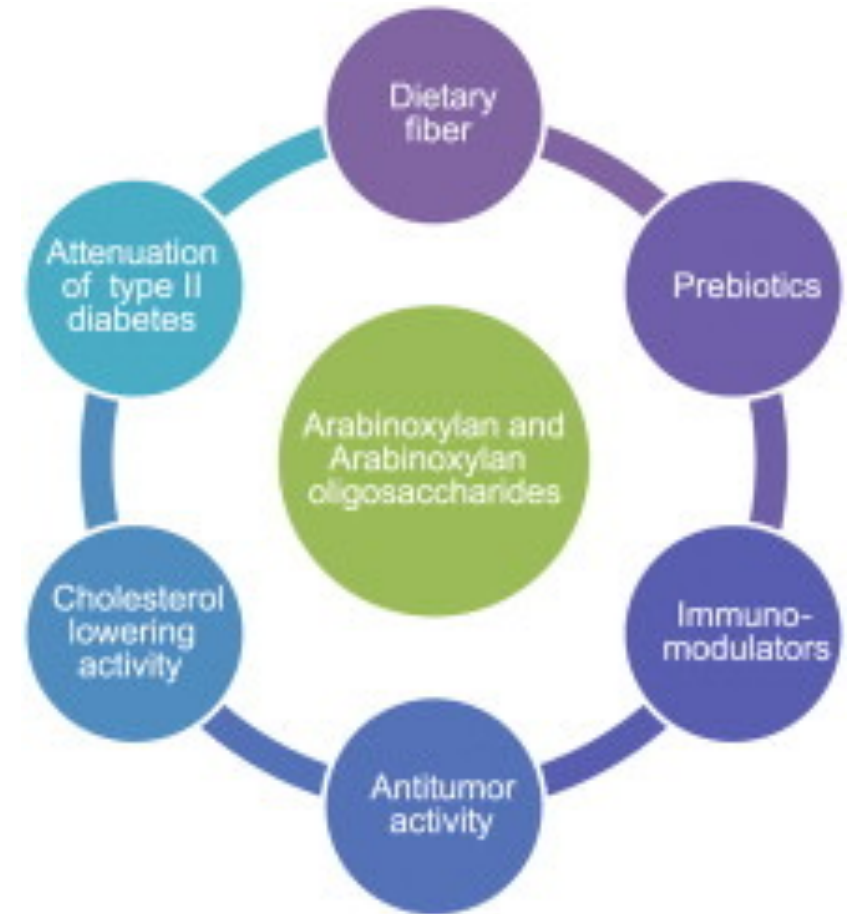


Arabinoxylans

↑ stool frequency and improve stool consistency through effect of SCFAs
↑ absorption of salts and water into the bowel

Studies showing benefits on blood sugar, TGs and cholesterol

Animal studies show an anti-inflammatory and immune-enhancing effect



Fructans

Polymers of fructose found in wheat, barley, onions, garlic, agave, artichokes, asparagus and leeks

Includes:

- Inulin (11-60 chain length)
- Oligofructose (3-10 chain length) derived from inulin
- Fructo-oligosaccharides (3-5 chain length) derived from sucrose

Rapidly fermented by *Bifidobacterium* and *Lactobacillus* which are preferentially stimulated to grow, causing significant changes in the composition of the gut microbiota

Food item	Inulin	Oligofructose (as fraction of inulin)
Banana (fresh)	0.5	0.5
Asparagus (fresh)	2.5	2.5
Chicory root (fresh)	17.5	9.6
Garlic (fresh)	12.5	5.0
Jerusalem artichoke (fresh)	18.0	13.5
Leeks (fresh)	6.5	5.2
Onions (fresh)	4.3	4.3
Wheat bran (fresh)	2.5	2.5
Wheat flour (baked)	2.4	2.4
Barley(fresh)	0.8	0.8
Rye (baked)	0.7	0.7

Content of inulin and oligofructose (g/100 g; midpoint of reported ranges) in various foods

Fructans

Estimates that grains account for approximately 70% of daily fructan intake in Western diet

Wheat and barley fructans produce similar amounts of SCFAs as inulin



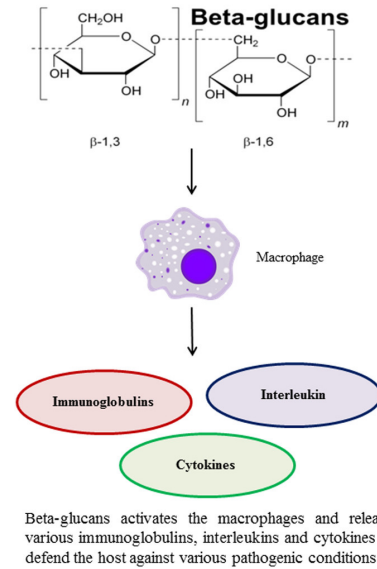
Beta-glucan

Polymers of glucose found grains, especially oats and barley

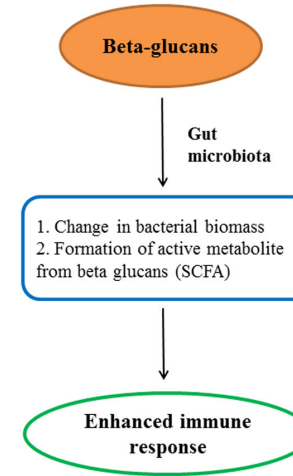
Can increase populations of *Bifidobacterium* and *Lactobacillus* in a dose-dependent manner

Increase SCFAs and immuno-enhancing effects

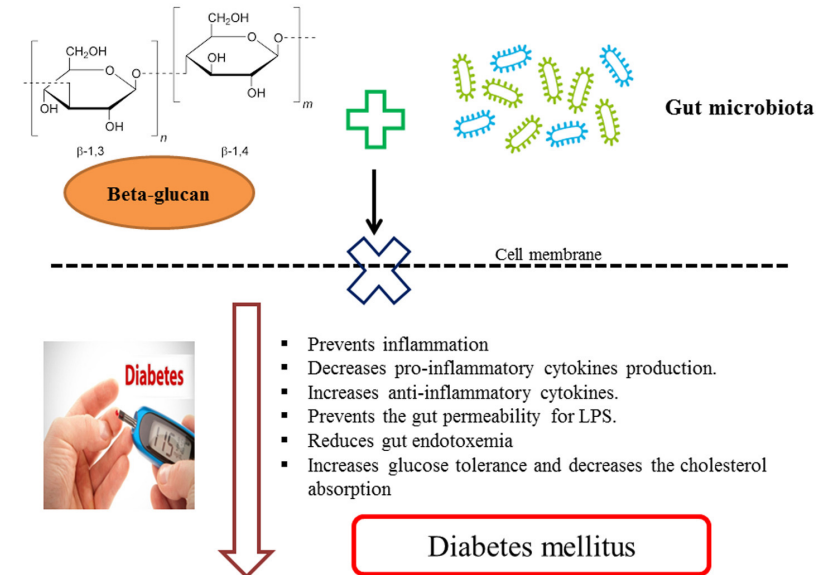
Favourable benefits on blood glucose could be mediated by gut microbiota



Possible involvement of gut microbiota in beta-glucans immunomodulatory action



Influence of beta-glucan and gut microbiota on diabetes mellitus



Resistant starch

Component of dietary fibre

CSIRO estimates put RS consumption of Australian adults at 3 to 9 g/d

Goal of 15-20 g/d recommended for optimal bowel health

Designation	Description	Examples
RS1	Physically inaccessible starch	Coarsely ground or whole-kernel grains
RS2	Granular starch	High-amylose maize starch, raw potato, raw banana starch
RS3	Retrograded starch	Cooked and cooled starchy foods
RS4	Chemically modified starches	Cross-linked starch
RS5	Amylose-lipid complex	Stearic acid-complexed high-amylose starch

Resistant starch – health benefits

Functions like fermentable soluble fibre

Changes microbial composition

Fermented by bacteria to SCFAs

BSL regulation and improvement in insulin sensitivity

Appetite regulation via SCFAs effect on appetite hormones (leptin, GLP-1 and peptide YY)



An acute change in diet (going from strictly animal-based to plant-based diet) alters microbial composition within just 24 h, with reversion to baseline within 48 h of diet discontinuation

Published: 11 December 2013

Diet rapidly and reproducibly alters the human gut microbiome

Lawrence A. David, Corinne F. Maurice, Rachel N. Carmody, David B. Gootenberg, Julie E. Button, Benjamin E. Wolfe, Alisha V. Ling, A. Sloan Devlin, Yug Varma, Michael A. Fischbach, Sudha B. Biddinger, Rachel J. Dutton & Peter J. Turnbaugh 

Nature **505**, 559–563(2014) | [Cite this article](#)



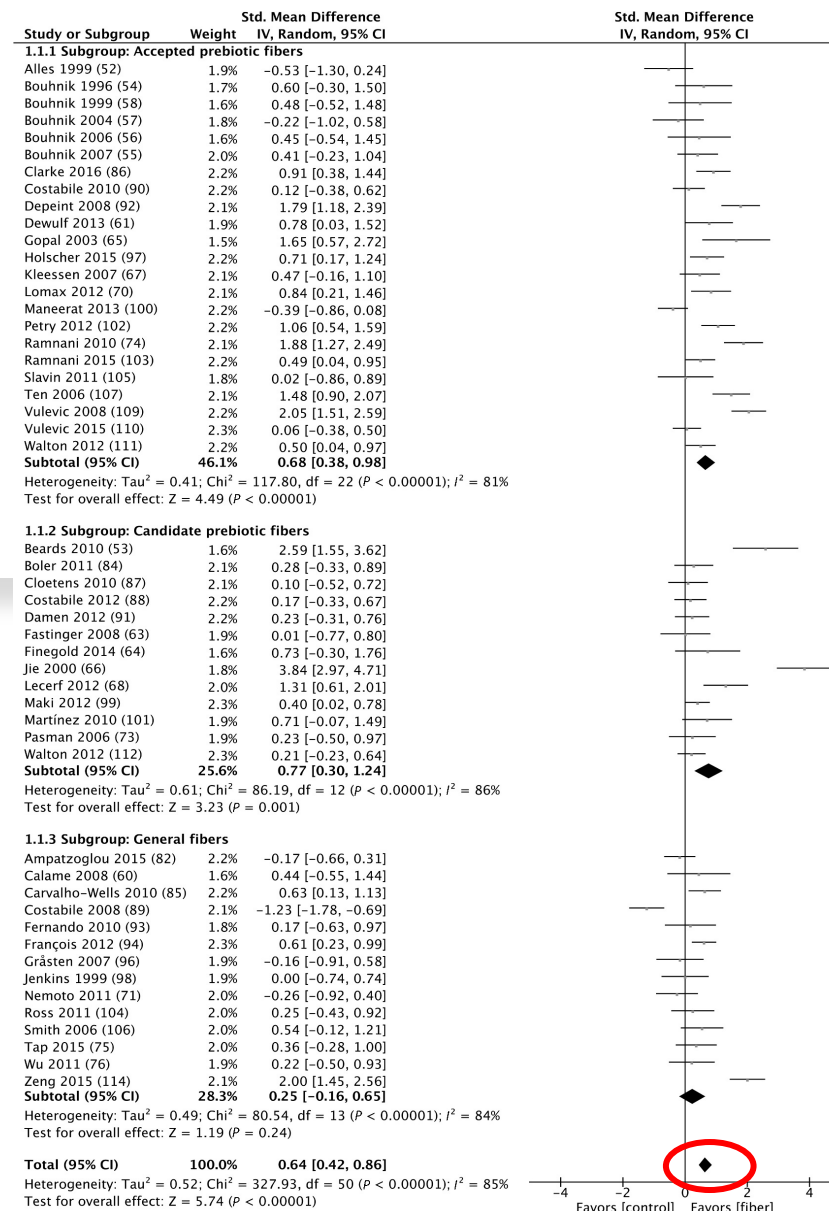
Dietary fiber intervention on gut microbiota composition in healthy adults: a systematic review and meta-analysis

Daniel So, Kevin Whelan, Megan Rossi, Mark Morrison, Gerald Holtmann, Jaimon T Kelly, Erin R Shanahan, Heidi M Staudacher, Katrina L Campbell ✉

The American Journal of Clinical Nutrition, nqy041, <https://doi.org/10.1093/ajcn/nqy041>

Published: 11 May 2018 Article history ▼

Dietary fibre interventions ↑ faecal abundance of *Bifidobacterium* and *Lactobacillus* as well as faecal butyrate concentration but did not affect α-diversity (number of distinct organisms)



ICD 2021 Cape Town Virtual @ICD2021CapeTown · 5h

What is the marker of a 'good' microbiota? Here are @ProfWhelan's "Microbiota Big 5" - Alpha diversity, Firmicutes: Bacteroidetes ratio, Bifidobacteria, Faecalibacterium prausnitzii and Akkermansia mucinophilia #ICD2021 #ICD2021Virtual

What is the marker of a 'good' microbiota?



Alpha diversity

Combination of the number (richness) of bacteria and evenness of distribution
Diversity is lower in obesity, diabetes, IBS, inflammatory bowel disease

Lozupone, Nature.
2012; 489(7415): 220-30



Firmicutes : Bacteroidetes ratio

The two major phyla of bacteria in the gut
Greater F:B ratio in people with low fibre intake and who are overweight

Magne et al, Nutrients
2020; 12: 1474



Bifidobacteria

Genus that colonises during infancy (HMO in breastmilk) and increased by prebiotics
Lower in many disorders of the gut (e.g. IBS, IBD)

Arbolea et al, Frontiers
Microbiol. 2016; 7: 1204



Faecalibacterium prausnitzii

Species with immunoregulatory / anti-inflammatory properties
Lower in people with IBD, and higher levels means longer remission

Miquel et al, Current Opinion
Microbiology 2013, 16:255-261



Akkermansia mucinophilia

Species that impacts metabolism and insulin sensitivity.
Preliminary evidence of beneficial impacts on body weight

Cani et al, Frontiers
Microbiol, 2017; 8: 1765.

Microbiota Big 5

McBurney, J Nutr. 2019; 149: 1882-1895.



4



17



What do whole-diet
intervention studies
with wholegrains
have to say about
the gut microbiota-
health link?



Bifidogenic effect of whole-grain wheat during a 12-week energy-restricted dietary intervention in postmenopausal women

E G Christensen, T R Licht, M Kristensen & M I Bahl 

European Journal of Clinical Nutrition **67**, 1316–1321 (2013) | [Cite this article](#)

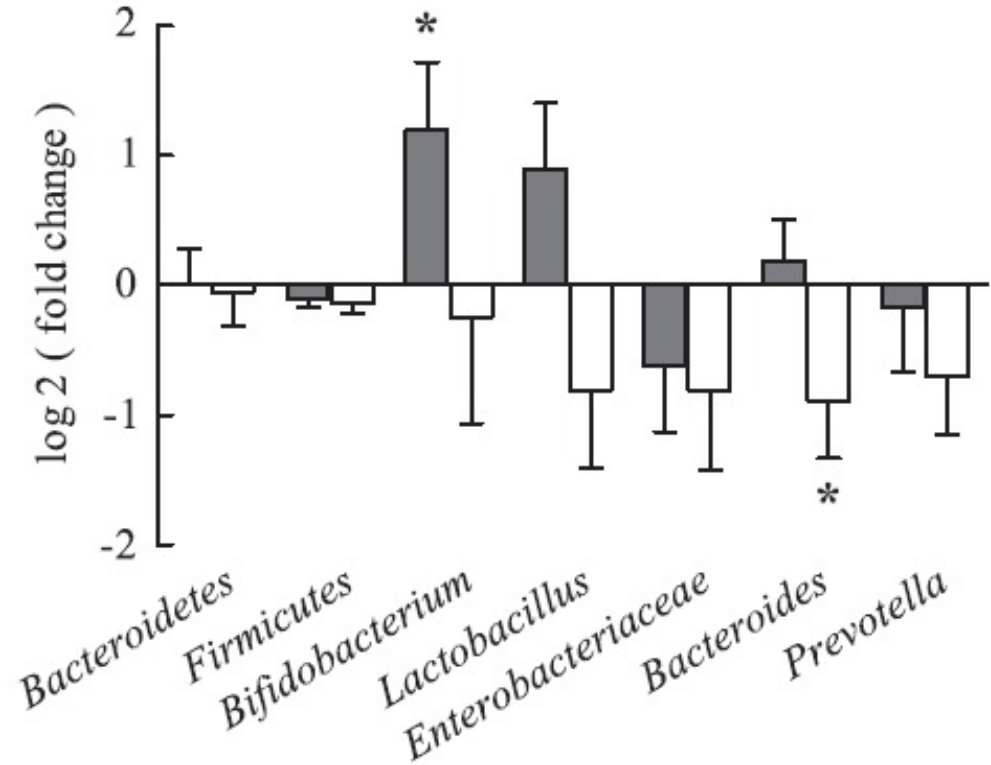
989 Accesses | 22 Citations | 3 Altmetric | [Metrics](#)

12-week parallel RCT in 79 women

Intervention of 105 g/d of wholegrain wheat to replace 2 MJ of habitual diet

Control group received refined-grain foods

Significant \uparrow *Bifidobacterium*



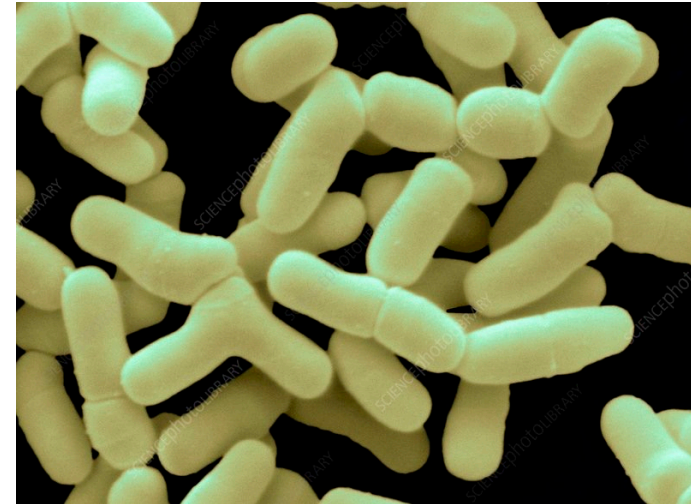


Whole-grain wheat breakfast cereal has a prebiotic effect on the human gut microbiota: a double-blind, placebo-controlled, crossover study

Published online by Cambridge University Press: 29 August 2007

Adele Costabile, Annett Klinder, Francesca Fava, Aurora Napolitano, Vincenzo Fogliano, Clare Leonard, Glenn R. Gibson and Kieran M. Tuohy

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3-week crossover RCT in 32 adults

Intervention of 48 g/d of wholegrain wheat cereal

Control group received refined-grain cereal

Significant ↑ *Bifidobacterium* and *Lactobacillus*

Bacterial group	Pre-WB		WB		Pre-WG		WG	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total bacteria	10.7	0.1	10.7	0.1	10.8	0.2	10.8	0.1
<i>Bacteroides</i> spp.	9.6	0.2	9.6	0.3	9.6	0.3	9.7	0.3
<i>Eubacterium rectale</i> group	10.1	0.2	10.0	0.2	10.0	0.1	10.1	0.1
<i>Bifidobacterium</i> spp.	8.9 ^a	0.4	8.8 ^b	0.4	8.5 ^c	0.5	9.3 ^{a,b,c}	0.4
<i>Atopobium</i> spp.	8.9	0.3	8.9	0.3	9.1	0.4	9.1	0.3
<i>Cl. histolyticum/perfringens</i> gp.	8.2	0.5	8.5 ^a	0.4	8.2 ^a	0.6	8.4	0.3
Lactobacilli/enterococci	8.0 ^{a,b}	0.4	8.4 ^{a,c,d}	0.2	8.1 ^{c,e}	0.4	8.7 ^{b,d}	0.2

WB, wheat bran; WG, whole-grain.

^{abcd}All values in one row with a common letter are significantly different from each other ($P < 0.05$, Tukey's post test).

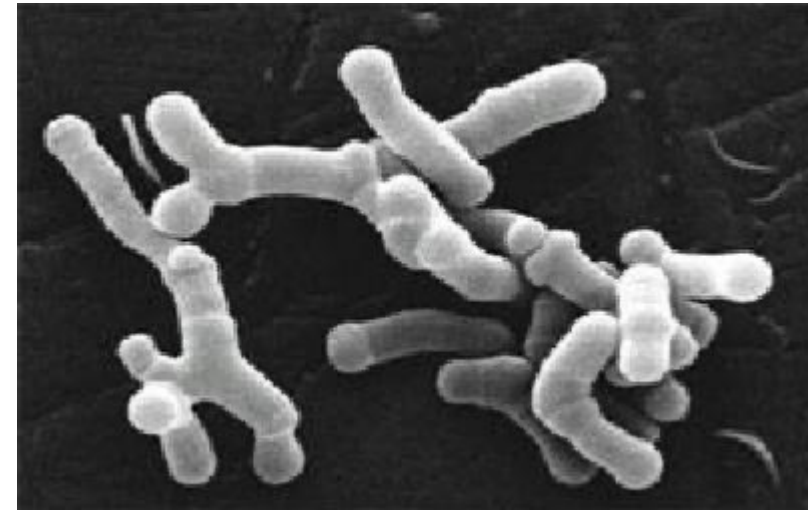


Determination of the *in vivo* prebiotic potential of a maize-based whole grain breakfast cereal: a human feeding study

Published online by Cambridge University Press: 21 May 2010

Andrew L. Carvalho-Wells, Kathrin Helmolz, Cecelia Nodet, Christine Molzer, Clare Leonard, Brigid McKeivith, Frank Thielecke, Kim G. Jackson and Kieran M. Tuohy

Show author information



3-week crossover RCT in 33 adults

Intervention of 48 g/d of wholegrain maize cereal

Control group received refined-grain cereal

Significant ↑ *Bifidobacterium*

Bacterial group	Pre WGM		Post WGM		Pre NWG		Post NWG		WO	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Bifidobacterium</i> spp.	9.53 ^a	0.32	9.81 ^{a,b,c,d}	0.26	9.48 ^b	0.26	9.62 ^c	0.33	9.48 ^d	0.20
<i>Lactobacillus/Enterococcus</i> group	8.78 ^a	0.25	8.87 ^{b,c}	0.27	8.69 ^b	0.27	8.77 ^d	0.26	8.52 ^{a,c,d}	0.21
<i>Atopobium</i> cluster spp.	9.63 ^{a,b}	0.27	9.94 ^{a,c}	0.30	9.64 ^{c,d}	0.30	9.95 ^{b,d}	0.26	9.75	0.23
<i>Bacteroides</i> – <i>Prevotella</i> spp.	9.96	0.33	9.95	0.29	10.01	0.38	10.03	0.33	10.03	0.25
REC cluster	9.90 ^a	0.25	9.98 ^c	0.22	9.90 ^b	0.25	10.07 ^{a,b,d}	0.29	9.80 ^{c,d}	0.33
<i>Clostridium histolyticum/perfringens</i> gp.	8.42	0.33	8.35	0.33	8.43	0.33	8.42	0.26	8.52	0.29
Universal bacterial probe	10.81	0.22	10.94	0.27	10.74	0.34	10.92	0.28	10.76	0.29
Total cells	10.90	0.16	11.02	0.18	10.98	0.21	11.01	0.21	10.91	0.25



Hypocholesterolemic and Prebiotic Effects of a Whole-Grain Oat-Based Granola Breakfast Cereal in a Cardio-Metabolic “At Risk” Population

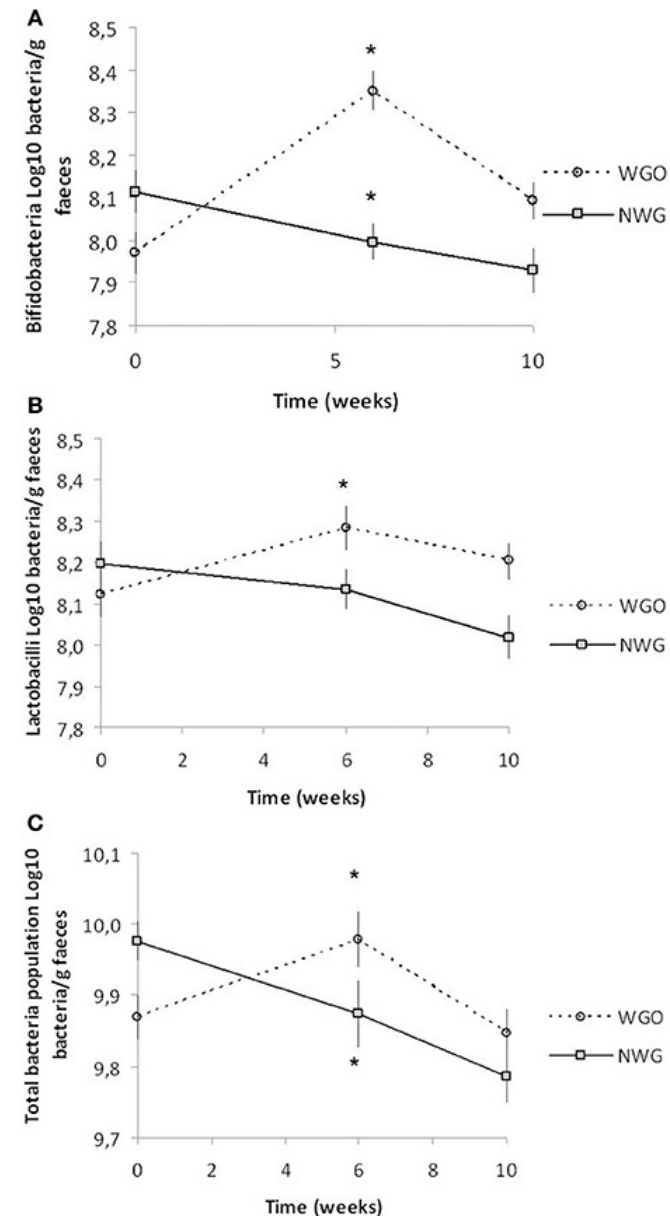
Michael L. Connolly^{1,2}, Xenofon Tzounis^{1,2}, Kieran M. Tuohy^{1,3*} and Julie A. Lovegrove^{1,2*}

6-week crossover RCT in 32 adults

Intervention of 45 g/d of wholegrain oat cereal

Control group received refined-grain cereal

Significant \uparrow *Bifidobacterium* and *Lactobacillus*



Gut bacteria selectively promoted by dietary fibers alleviate type 2 diabetes

LIPING ZHAO , FENG ZHANG , XIAOYING DING , GUOJUN WU, YAN Y. LAM , XUEJIAO WANG, HUAQING FU, XINHE XUE, CHUNHUA LU, [...] CHENHONG ZHANG 

+24 authors [Authors Info & Affiliations](#)

SCIENCE • 9 Mar 2018 • Vol 359, Issue 6380 • pp. 1151-1156 • DOI: 10.1126/science.aao5774

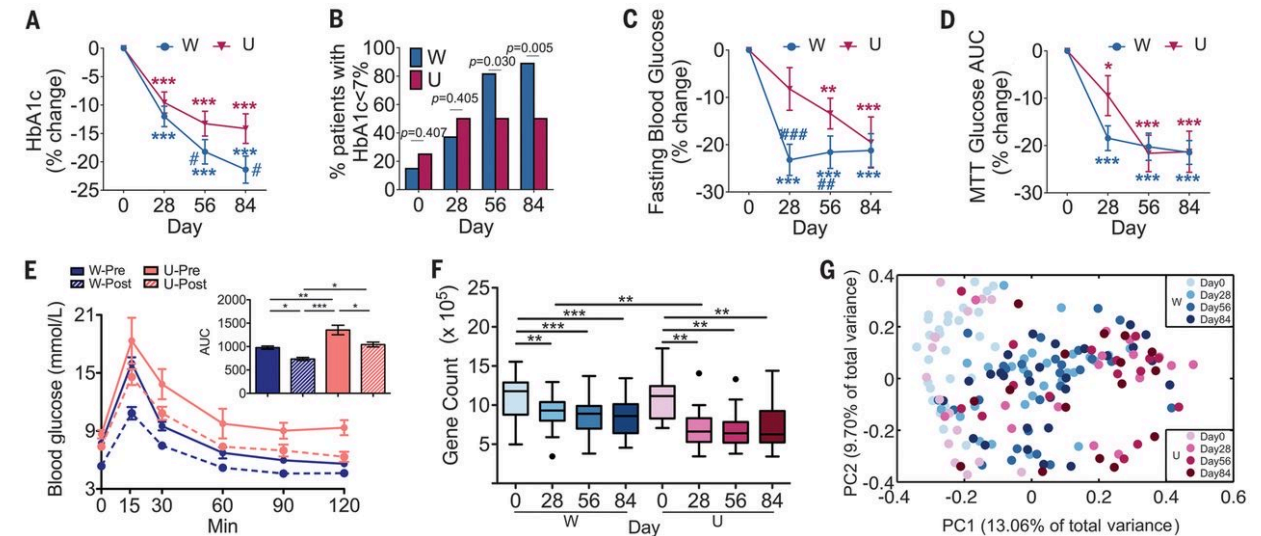
43 people with T2DM randomised to a diet high in traditional Chinese prebiotic foods and wholegrains or usual care regular diet for 3 m

Greater improvements in HbA1c and FPG in intervention group

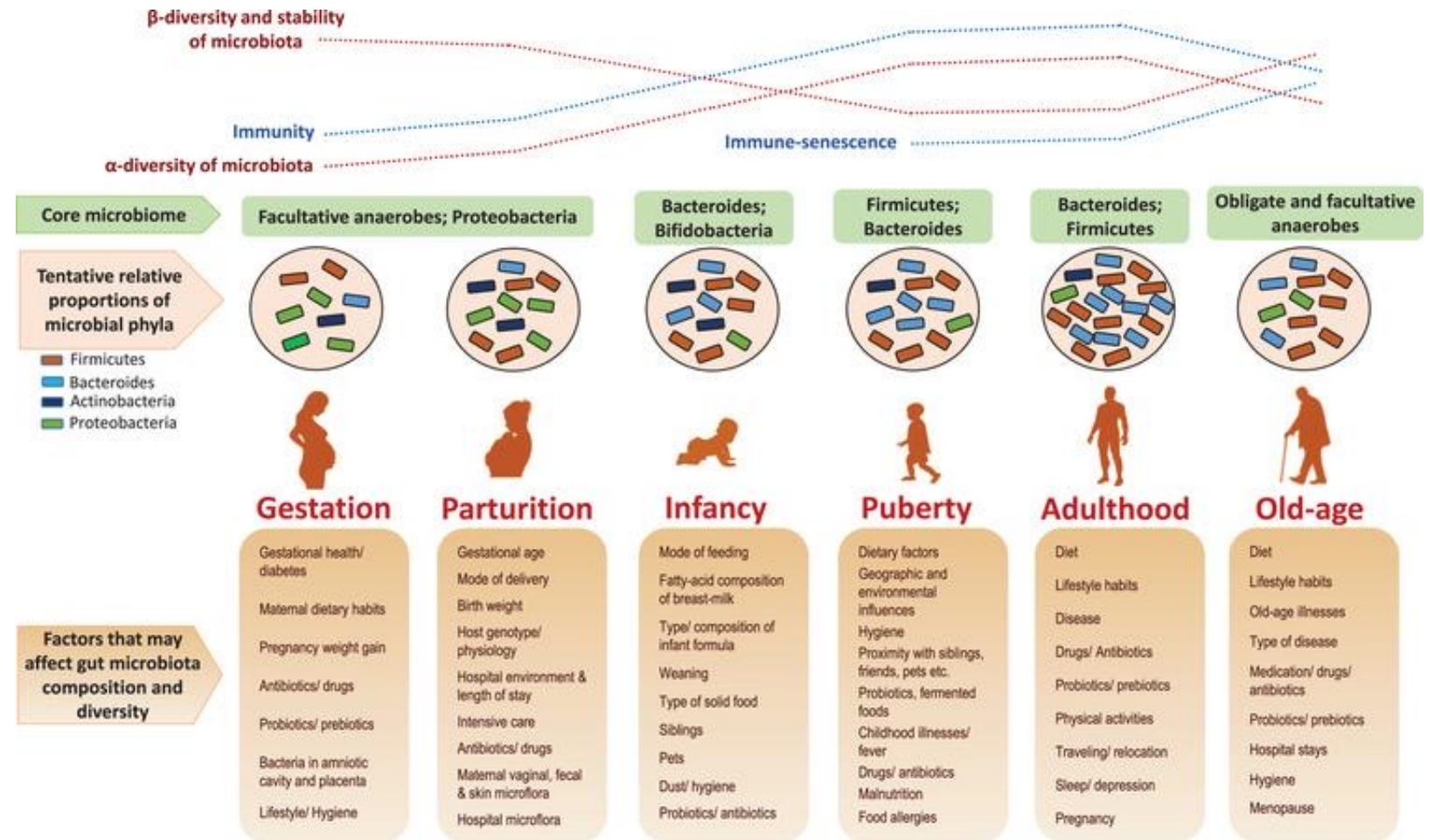
↑ gene diversity for carbohydrate metabolism and SCFA metabolism in intervention group

15 bacterial strains involved in SCFA production found at ↑ levels

Fibre → ↑ specific gut bacteria → ↑ SCFAs → release of insulin secreting hormones



A place for
wholegrain
prebiotics
throughout the
lifecycle for us
and our
microbes



Going with the grain

Choose wholegrains where possible

Smart swaps

- White crackers to whole grain crackers
- White bread to whole grain bread
- White rice to brown rice, barley or quinoa
- White flour to wholegrain flours such as wholemeal flour

Creative salads: try freekeh, brown rice, barley, buckwheat or even millet in your next salad

Blend it: add rolled oats into a smoothie



Going with the grain

Choose a wholegrain breakfast cereal

Choose wholegrain snacks

Experiment with different grains such as buckwheat, bulgur, millet, quinoa, sorghum, whole rye or barley

Mix up your flours when baking: swap out some of the white flour for wholemeal flour

If following a gluten-free diet, go for options such as millet, quinoa, buckwheat, sorghum or amaranth



Wrap Up

A wide variety of foods and substances are now considered prebiotics

Health effects of prebiotics are diverse and growing as the evidence base grows

Grains contain a unique mix of prebiotic fibres: arabinoxylans, fructans, beta-glucan and resistant starch which can change the gut microbiota and increase SCFA production

Dietary changes focussed on increasing more prebiotic fibre coming from wholegrain foods at a whole-diet level are effective in causing favourable gut microbiota changes



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