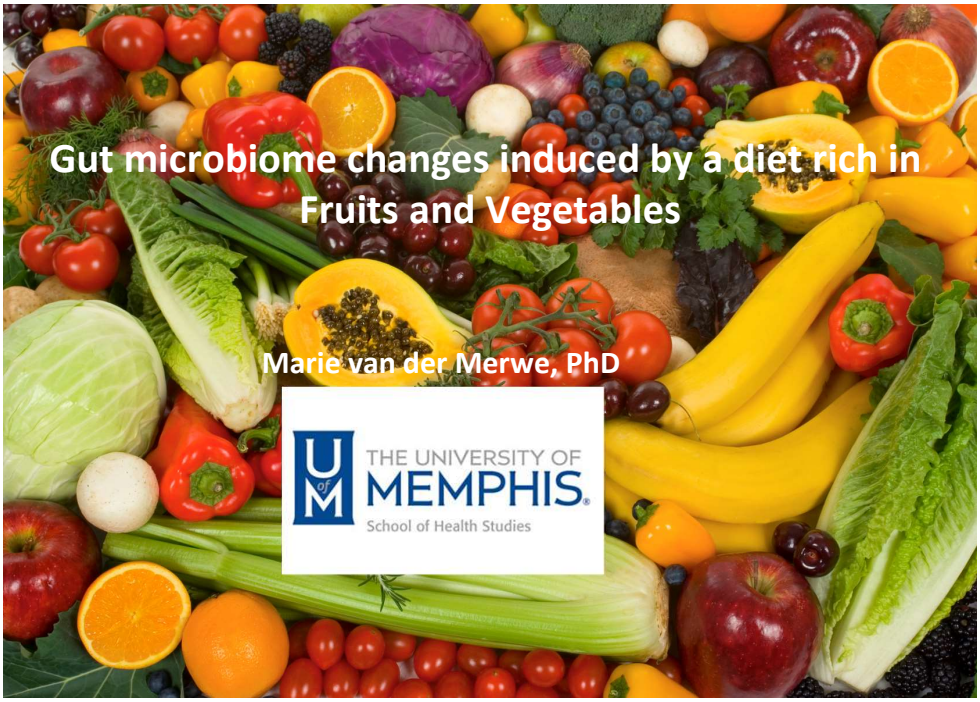


1

Disclosures

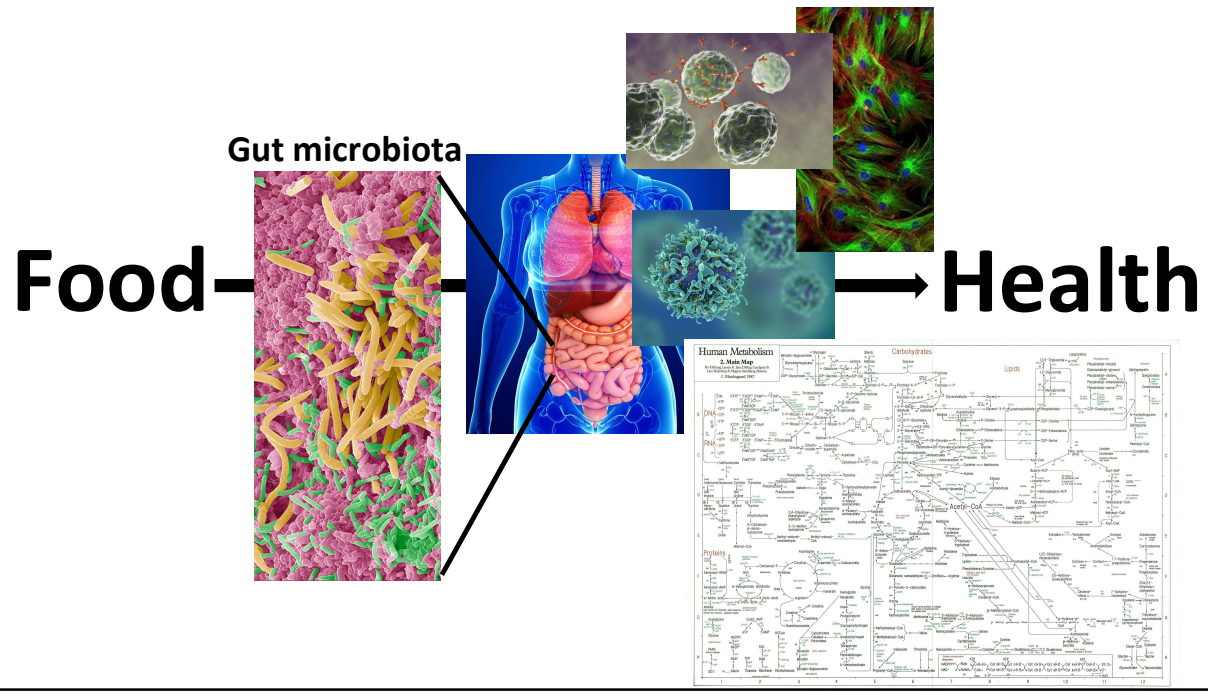
I receive research support from:

- **The JuicePlus+ Company**
- **Bergstrom Nutrition Inc.**
- **Mannatech**

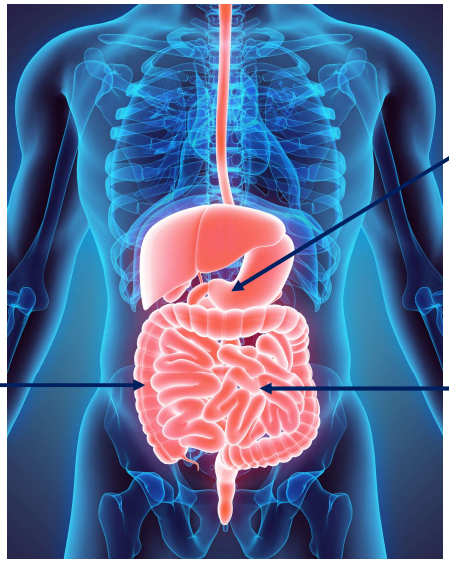
2

Learning Objectives

1. Describe how **diet** influences **gut microbial** function.
2. Identify **components** of fruits and vegetables that alter microbial composition.
3. Describe changes in the gut microbiome induced by a diet rich in fruit and vegetables that will improve **patient health**.



Gut Microbiome



Colon
$10^{10} – 10^{12}$ CFU/mL
Bacteroides
Prevotella
Facaelibacterium
Ruminococcus
Roseburia
Clostridium
Bifidobacteria
Collinsella
Desulfovibrio
Bilophila
Akkermansia
Methanobrevibacter

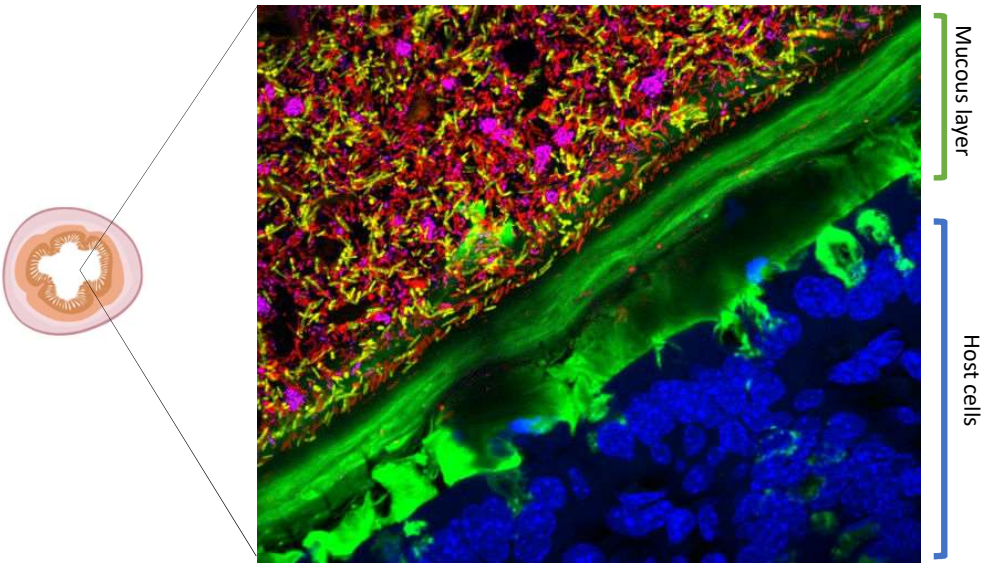
Stomach & Duodenum
10^{1}-10^{2} CFU/ml
Helicobacteria
Streptococci

Jejunum & Ileum
10^{4}-10^{8} CFU/ml
Lactobacilli
Streptococci
Bacteroides
Bifidobacteria
Fusobacteria

https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

5

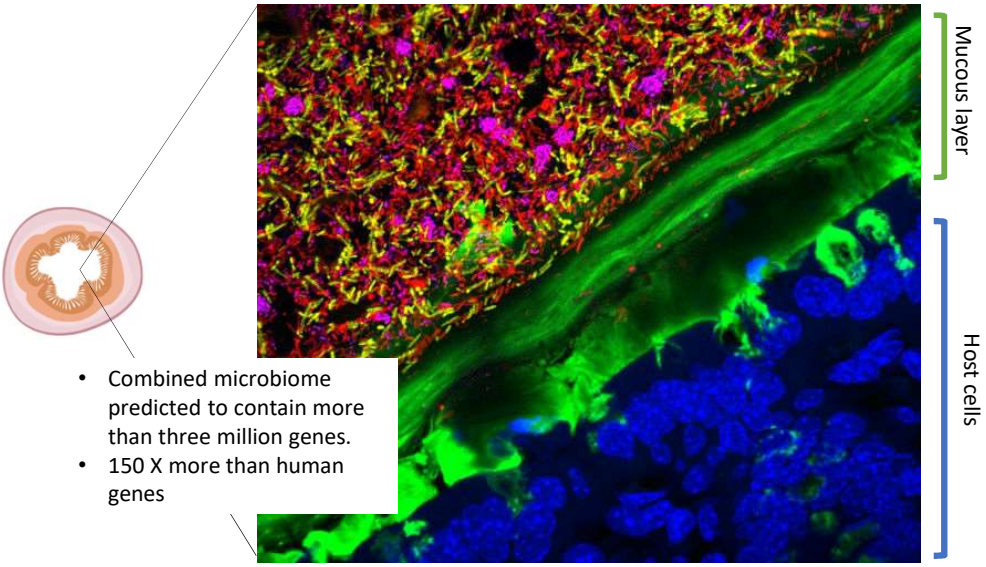
Gut Microbiome



Tropini C et al. Cell Host Microbe, 2017

6

Gut Microbiome

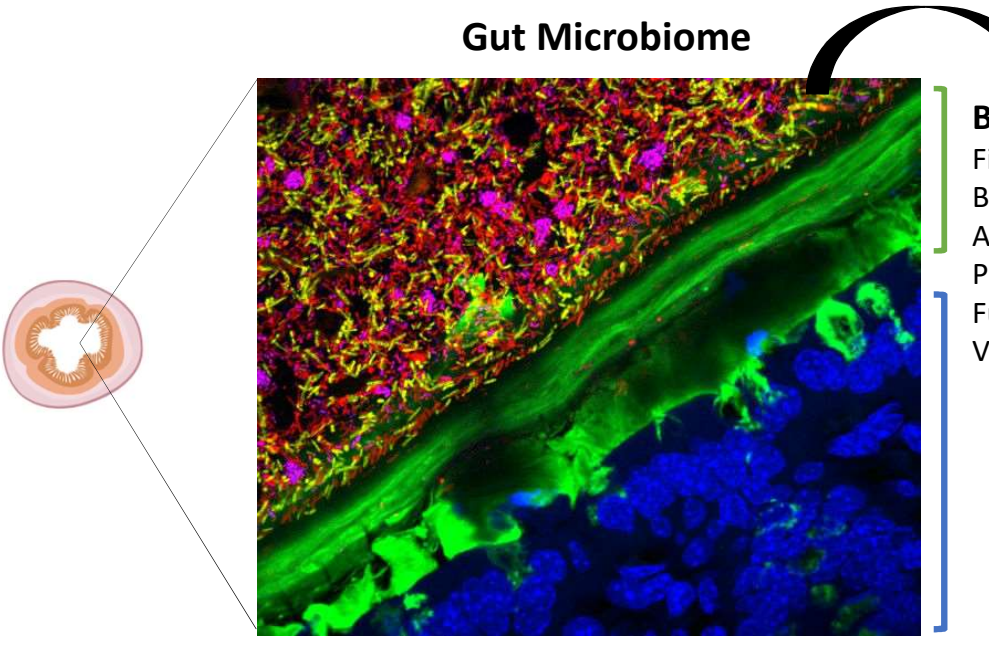


- Combined microbiome predicted to contain more than three million genes.
- 150 X more than human genes

Tropini C et al. Cell Host Microbe, 2017

7

Gut Microbiome

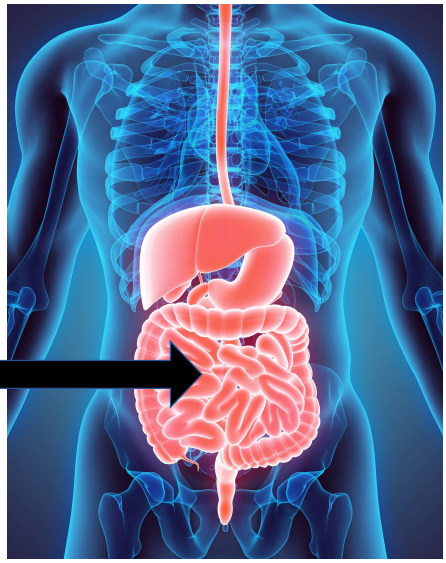


Tropini C et al. Cell Host Microbe, 2017

8

Factors that effect the Microbiome

- Birth mode
- Infant Feeding
- Solid food

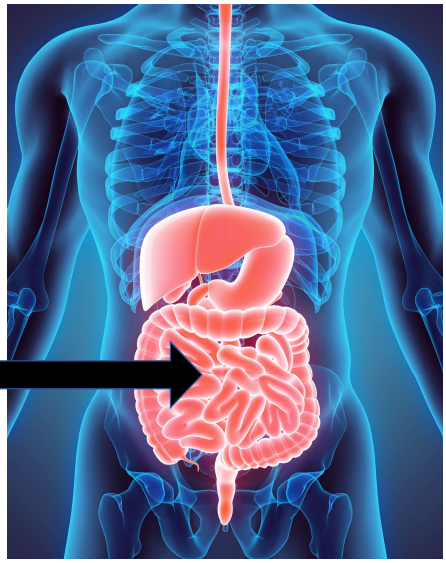


https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

9

Factors that effect the Microbiome

- Birth mode
- Infant Feeding
- Solid food



- Genetics
- Host physiology
  - Age
  - Stress
  - Exercise
  - Diseases
- Environment
  - Living conditions
  - Medications
  - DIET

https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

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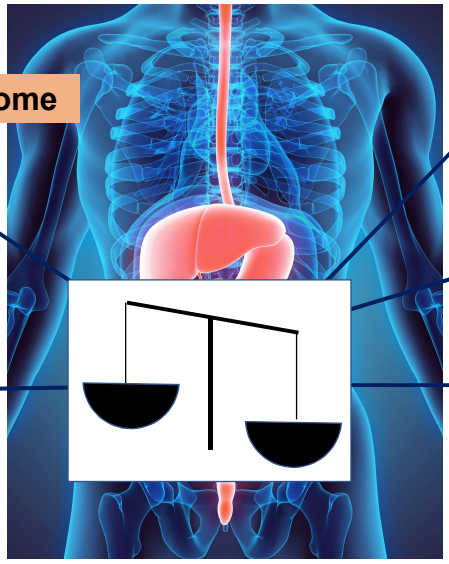
Dysbiosis



Obesity & Metabolic syndrome

Inflammatory bowel disease

Colon cancer

Autoimmune diseases

Neurological disorders

https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

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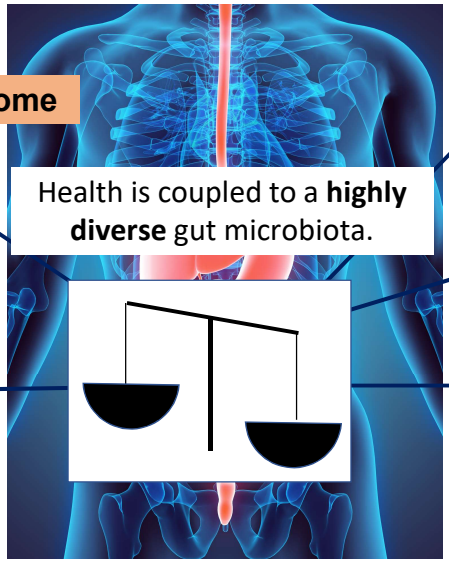
Dysbiosis



Obesity & Metabolic syndrome

Inflammatory bowel disease

Health is coupled to a **highly diverse** gut microbiota.

Colon cancer

Autoimmune diseases

Neurological disorders

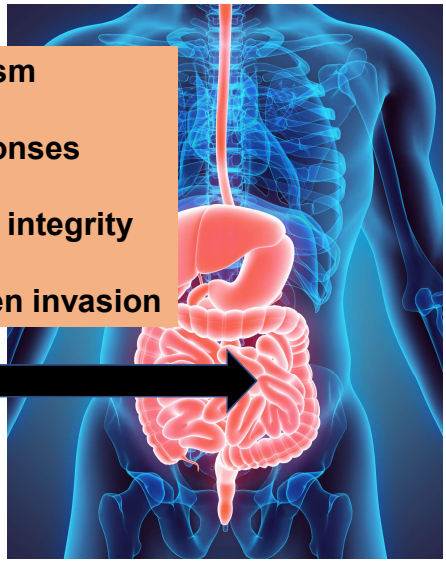
https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

12

13

Functions of the Microbiome

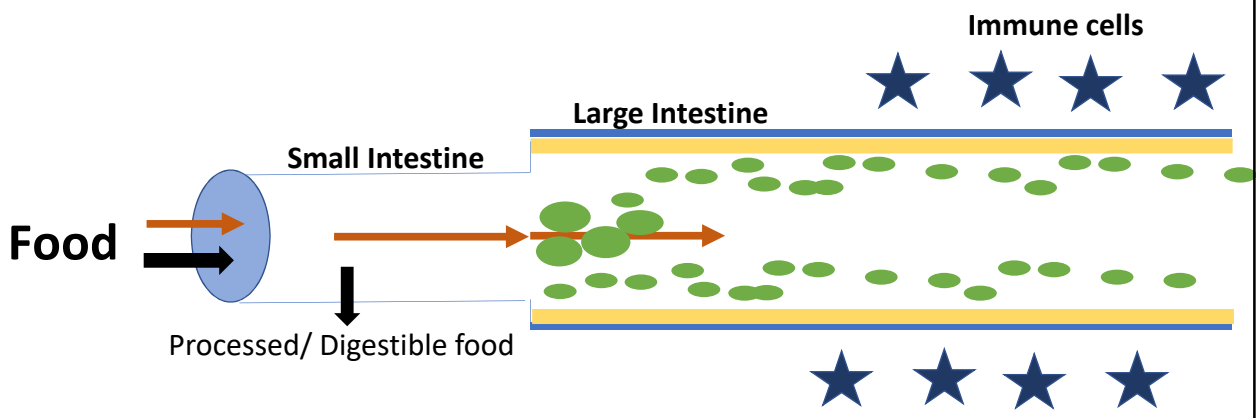
- Regulate host Metabolism
- Modulate Immune responses
- Maintain gut membrane integrity
- Protect against pathogen invasion



https://www.rn.com/uploadedImages/StaffCare/Content/Resource_Center/Gastrointestinal%20System.jpg

14

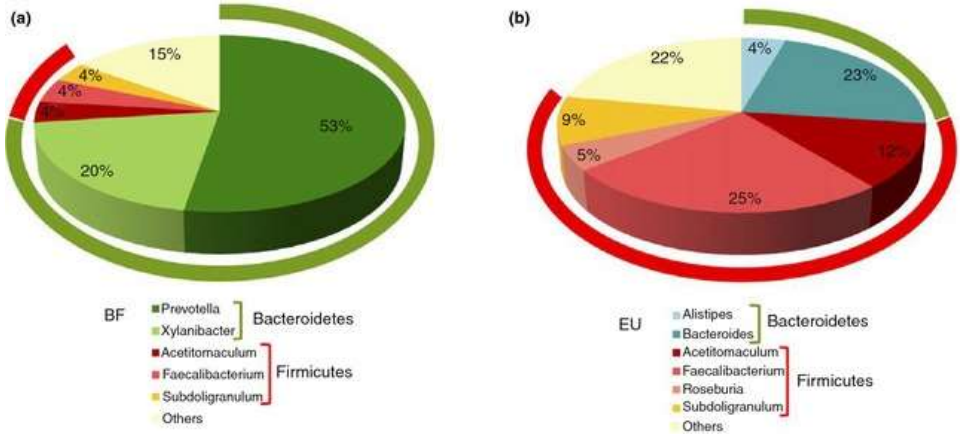
Digestive tract



MAC: “microbiota-accessible carbohydrate”

15

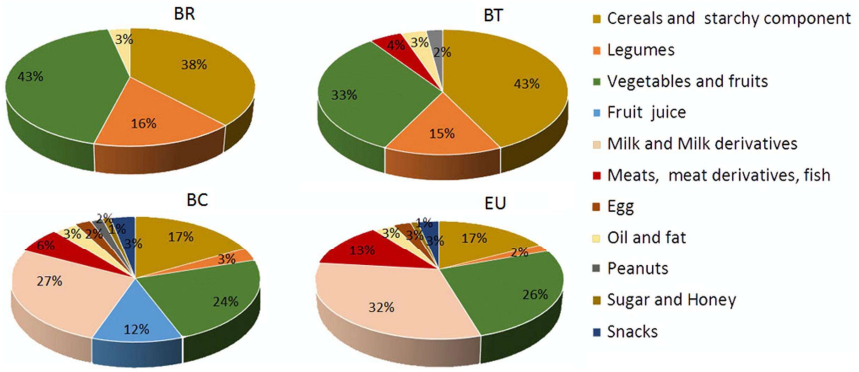
Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa

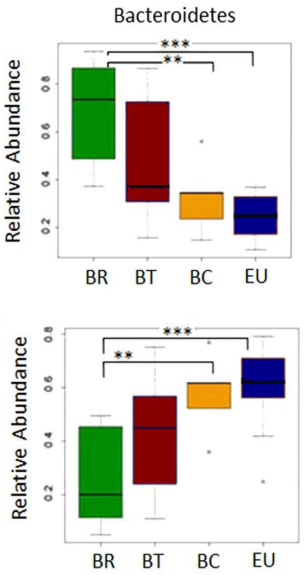


De Filippo C, Cavalieri D, Di Paola M, *et al. Proc Natl Acad Sci* USA 2010; 107: 14691–6.

16

Dietary habit modification play a role on shaping the gut microbiome

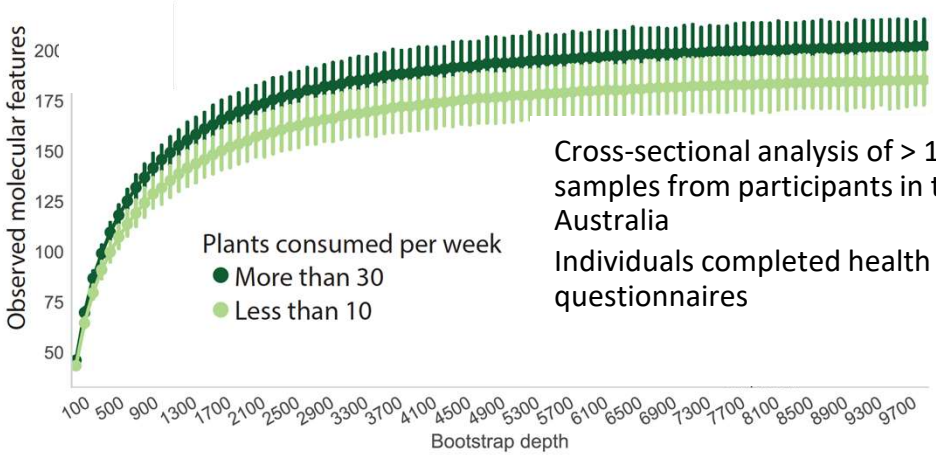




De Filippo C, Di Paola M, *et al. Front Microbiol.* 2017

17

Individuals that consumed more plants had greater bacterial diversity

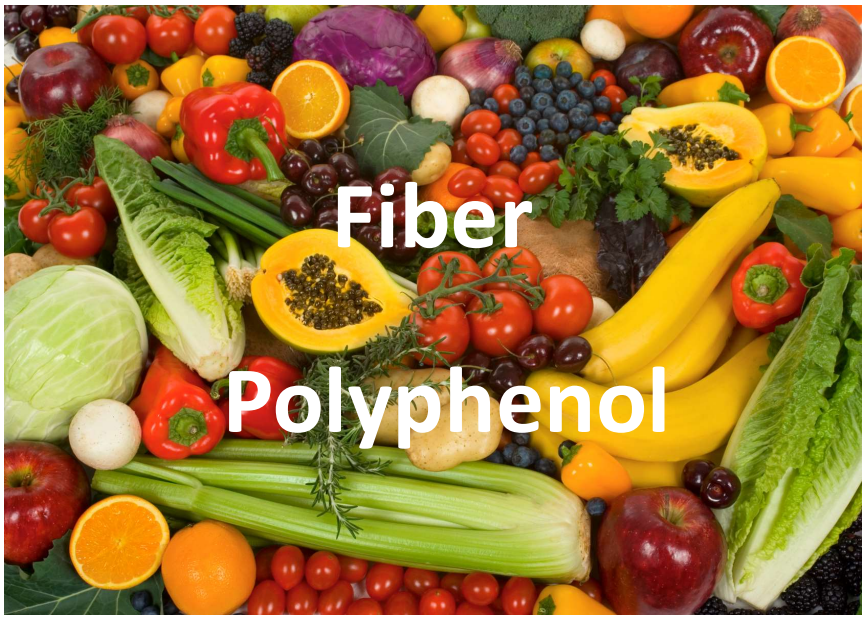


Cross-sectional analysis of > 10,000 fecal samples from participants in the US, UK, and Australia

Individuals completed health status and dietary questionnaires

McDonald D, (2018). American Gut: an open platform for citizen science microbiome research. *mSystems*, 3(3) e00031-18

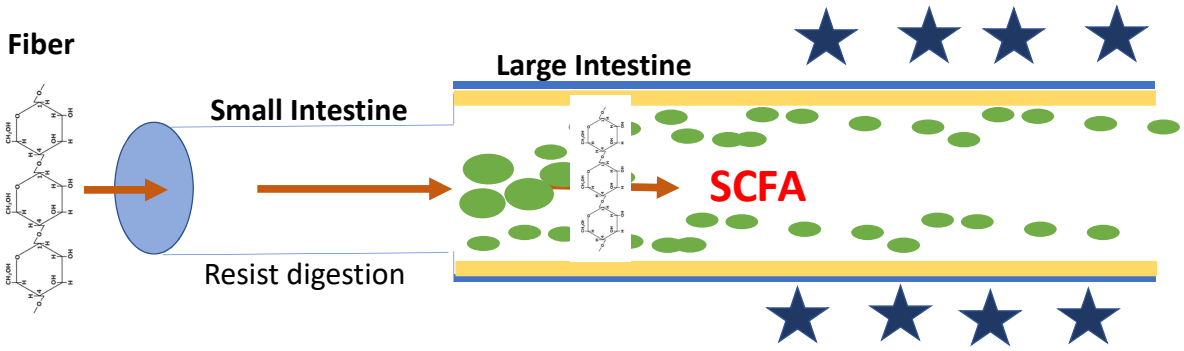
18



19

Fiber

- Carbohydrate polymers that are not digested by human-encoded enzymes in the small intestine.

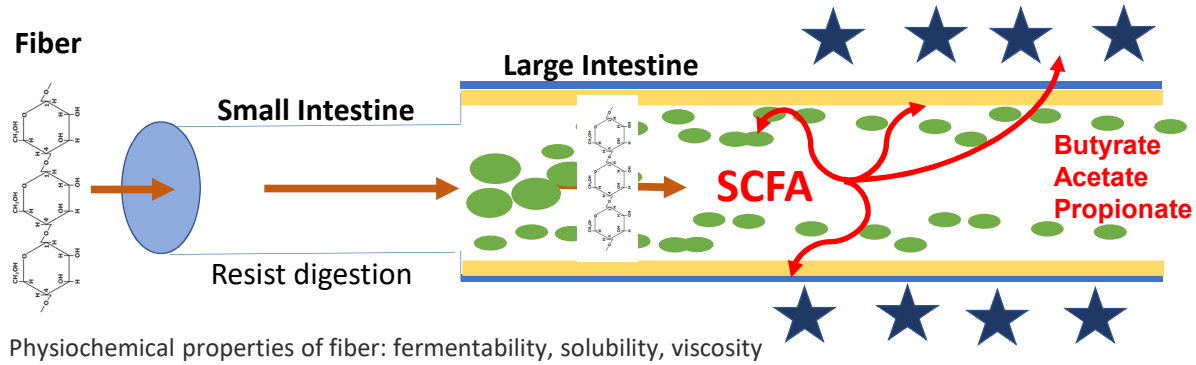


- Adequate Intake recommendation: **38 g/day -** men, **25 g/day –** women.
- The average American consumes ~**17 g/day**.

20

Fiber

- Carbohydrate polymers that are not digested by human-encoded enzymes in the small intestine.



- Physiochemical properties of fiber: fermentability, solubility, viscosity
  - Insoluble → **Cellulose**
  - Soluble/ ⬆viscosity →**Psyllium**
  - Soluble/non-viscous/ ⬆fermentable → **Inulin**

- **Effect on microbiota will vary based on fiber type.**

21

Fiber

- **Prebiotic** - Food components that can manipulate the microbiota to benefit the host.


nature REVIEWS GASTROENTEROLOGY & HEPATOLOGY

Consensus Statement | 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) | Download Citation

"substrate that is selectively utilized by host microorganism conferring a health benefit."

Accepted prebiotics – fiber types : galacto-oligosaccharides, fructo-oligosaccharides, inulin → pulses, grains, fruits and vegetables.

- Bifidogenic effect through B-fructosidase and B-galactosidase

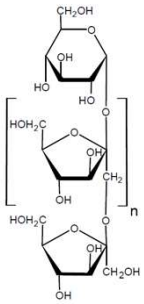
- Increase *Bifidobacteria* → Replace pathogen

22

Fiber - Inulin

Food Sources

- Wheat
- Bananas
- Garlic
- Onion
- Agave
- Chicory root



British Journal of Nutrition (2018), **119**, 176–189
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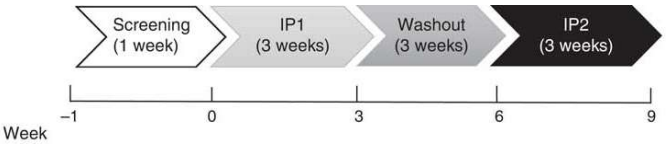
doi:10.1017/S0007114517003440

Habitual dietary fibre intake influences gut microbiota response to an inulin-type fructan prebiotic: a randomised, double-blind, placebo-controlled, cross-over, human intervention study

Genelle Healey[1,2]*, Rinki Murphy[3], Christine Butts[2], Louise Brough[1], Kevin Whelan[4] and Jane Coad[1]
[1]*School of Food and Nutrition, Massey Institute of Food Science and Technology, Massey University, Palmerston North 4442, New Zealand*
[2]*Food, Nutrition and Health, The New Zealand Institute for Plant & Food Research Limited, Palmerston North 4474, New Zealand*
[3]*Faculty of Medical and Health Sciences, The University of Auckland, Auckland 1142, New Zealand*
[4]*Faculty of Life Sciences and Medicine, Diabetes and Nutritional Sciences Division, King's College London, London SE1 9NH, UK*

(Submitted 4 May 2017 – Final revision received 29 October 2017 – Accepted 3 November 2017 – First published online 8 January 2018)



16 g/d inulin-type fructan for 3 weeks

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Fiber - Inulin

	Placebo (*n* 33)				Prebiotic (*n* 34)			
	Before intervention		After intervention		Before intervention		After intervention	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SCFA (μmol/g)								
Acetate	31·78	17·80	33·80	18·97	31·53	18·97	39·50	20·96
Butyrate	9·75	6·12	9·44	5·62	8·54	5·48	10·16	5·62
Propionate	10·09	6·19	11·63	7·78	10·03	7·83	11·94	7·47
Sum of SCFA	55·52	28·69	59·48	32·28	54·28	31·16	65·51	32·48
Phylum (% relative abundance)								
Actinobacteria	10·88	6·43	10·84	7·24	10·98	7·87	19·95**	10·20
Bacteroidetes	14·30	12·09	13·09	8·39	14·55	10·70	12·46	8·33
Firmicutes	72·90	11·31	73·85	11·02	72·41	10·75	65·71**	11·03
Proteobacteria	0·43	0·40	0·51	0·61	0·54	0·69	0·36‡	0·42
Verrucomicrobia	0·33	0·66	0·38	0·85	0·29	0·45	0·17	0·33
Genus (% relative abundance)								
Bifidobacterium	6·56	5·21	6·50	5·88	6·69	6·37	15·07**	8·54 *
Collinsella	3·36	2·52	3·15	2·80	3·07	2·82	3·81	2·79
Bacteroides	6·49	3·81	6·45	4·31	6·80	4·19	5·86	3·40
Prevotella	5·36	12·16	3·66	5·98	5·20	9·12	4·85	7·98
Lactobacillus	0·24	0·92	0·44	1·96	0·26	0·86	1·26	3·83
Lachnospiraceae, other, unknown genus	2·07	1·11	1·91	1·24	1·86	1·18	1·55	0·62
Lachnospiraceae, unknown genus	13·27	5·79	13·43	5·62	12·55	6·22	14·74	6·30
Blautia	10·78	5·81	9·45	4·43	9·90	4·83	7·67	3·88
Coprococcus	3·80	1·83	4·16	2·20	4·50	2·54	3·55*	1·65 *
Dorea	1·65	0·86	1·61	0·86	1·75	0·96	1·20*	0·66 *
Ruminococcus (Lachnospiraceae)	1·85	1·66	1·95	1·64	2·11	1·59	1·15**	1·04 *
Ruminococcaceae, unknown genus	16·33	4·82	16·86	4·29	15·24	4·01	14·50	4·12
Faecalibacterium	0·47	0·32	0·53	0·30	0·41	0·22	0·61‡	0·32 *
Oscillospira	1·10	0·67	1·11	0·70	1·08	0·53	0·78*	0·46
Ruminococcus (Ruminococcaceae)	5·60	3·73	5·52	4·00	5·49	3·76	4·40	3·32
Dialister	0·77	1·15	1·00‡	1·56	1·07	1·72	0·94	1·59

Healy et al. *British Journal of Nutrition*, 2018

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Fiber - Inulin

	Placebo (*n* 33)				Prebiotic (*n* 34)				
	Before intervention		After intervention		Before intervention		After intervention		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
SCFA (μmol/g)									
Acetate	31·78	17·80	33·80	18·97	31·53	18·97	39·50	20·96	
Butyrate	9·75	6·12	9·44	5·62	8·54	5·48	10·16	5·62	
Propionate	10·09	6·19	11·63	7·78	10·03	7·83	11·94	7·47	
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Phylum (% relative abundance)									
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Firmicutes	72·90	11·31	73·85	11·02	72·41	10·75	65·71**	11·03	
Proteobacteria	0·43	0·40	0·51	0·61	0·54	0·69	0·36‡	0·42	
Verrucomicrobia	0·33	0·66	0·38	0·85	0·29	0·45	0·17	0·33	
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Collinsella	3·36	2·52	3·15	2·80	3·07	2·82	3·81	2·79	
Bacteroides	6·49	3·81	6·45	4·31	6·80	4·19	5·86	3·40	
Prevotella	5·36	12·16	3·66	5·98	5·20	9·12	4·85	7·98	
Lactobacillus	0·24	0·92	0·44	1·96	0·26	0·86	1·26	3·83	
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Lachnospiraceae, unknown genus	13·27	5·79	13·43	5·62	12·55	6·22	14·74	6·30	
Blautia	10·78	5·81	9·45	4·43	9·90	4·83	7·67	3·88	
Coprococcus	3·80	1·83	4·16	2·20	4·50	2·54	3·55*	1·65	*
Dorea	1·65	0·86	1·61	0·86	1·75	0·96	1·20*	0·66	*
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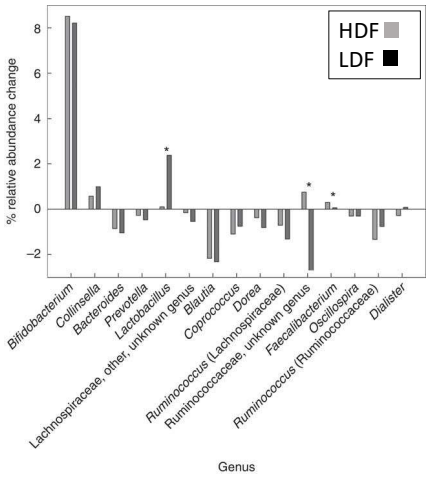

Healy et al. *British Journal of Nutrition*, 2018

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Fiber - Inulin

- **Microbial changes**
  - Increased ***Bifidobacterium*** and ***Faecalibacterium prausnitzii*** with16 g/d inulin/oligofructose for 12 weeks[1]
  - Dose dependent increase ***Bifidobacterium*** with Agave Inulin supplementation for 21 days[2]

1. Dewulf EM, et al. 2013, *Gut*; 62: 1112-21.
2. Holscher HD, et al. 2015, *J Nutr*; 145:2025–32

- **Physiological changes**
  - Immunomodulation – Decreased high sensitivity CRP, IL-6 and/or TNF-α, and endotoxin[1]
  - Appetite control – Increase PYY[2,3]
  - Glycemia – Improve postprandial glucose response[3]

1. Fernandes R, et al. 2017, *Clinical Nutrition*.36(5), 1197-1206
2. Parnell JA, et al. 2009, *AJCN* 2009; 89:1751–59.
3. Cani PD, et al. 2009, *AJCN*, 90(5), 1236-43.

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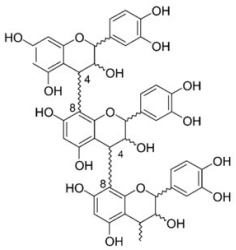
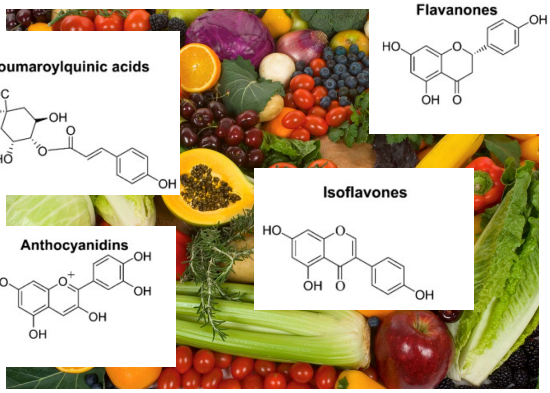
Polyphenols

- 8000 Polyphenols have been identified
  - **•Flavonoids**
  - **•Lignans**
  - **•Phenolic Acids**
  - **•Stilbenes**

  Fruits, vegetables, cereal, tea, coffee, cocoa, wine

Procyanidins





- Studies focused on anti-oxidant function.

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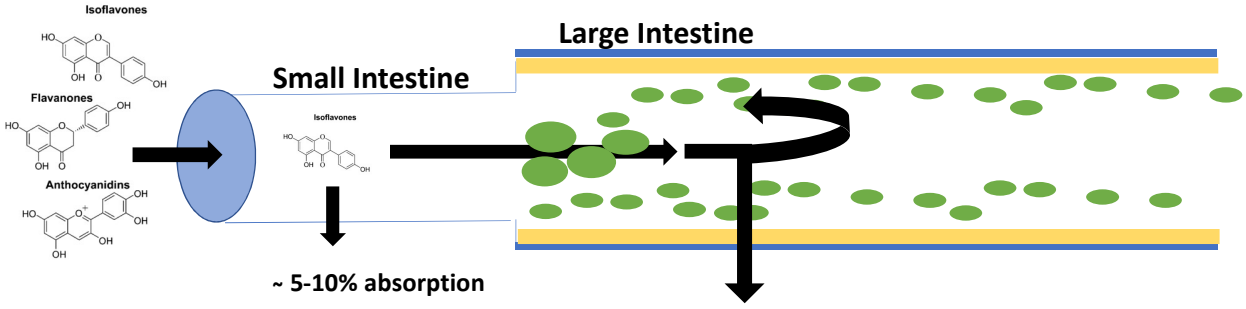
Polyphenols

- Alter microbiome
- Variation in community of gut microbiota alter biochemical fate of polyphenols.



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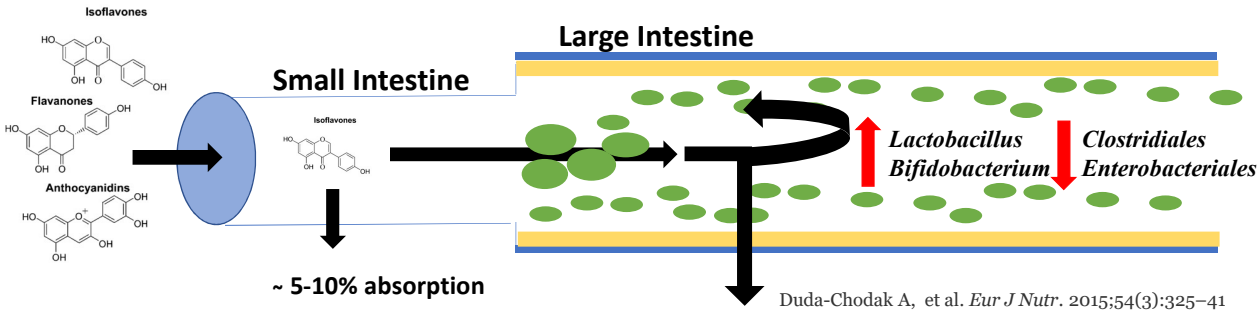
Polyphenols

- Alter microbiome
- Variation in community of gut microbiota alter biochemical fate of polyphenols.

Blueberries Grapes Cranberry Plum



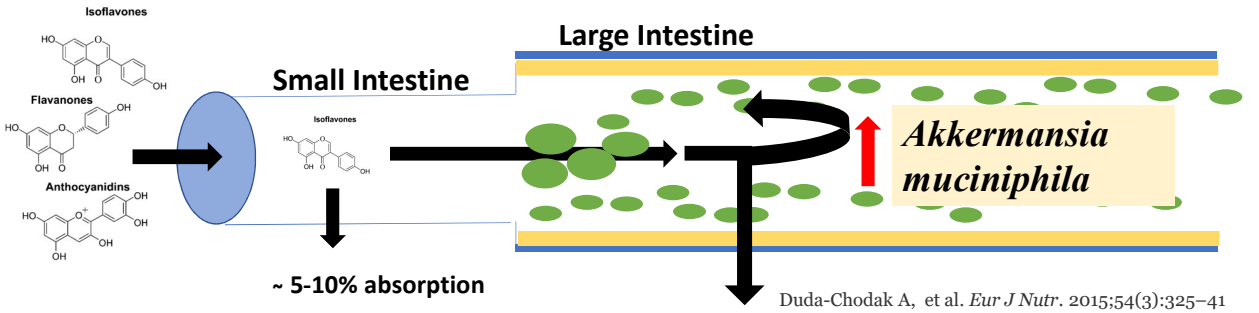
Duda-Chodak A, et al. *Eur J Nutr*. 2015;54(3):325–41
Anhe FF, et al. *Curr Obesity Reports*. 2015;4(4):389–400

29

Polyphenols

- Alter microbiome
- Variation in community of gut microbiota alter biochemical fate of polyphenols.

Berries - Proanthocyanidins



Duda-Chodak A, et al. *Eur J Nutr*. 2015;54(3):325–41
Anhe FF, et al. *Curr Obesity Reports*. 2015;4(4):389–400

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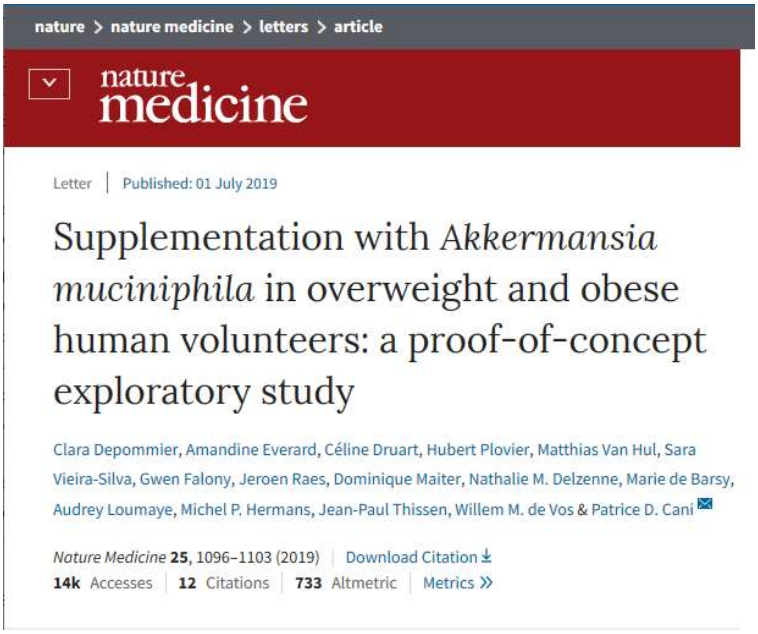
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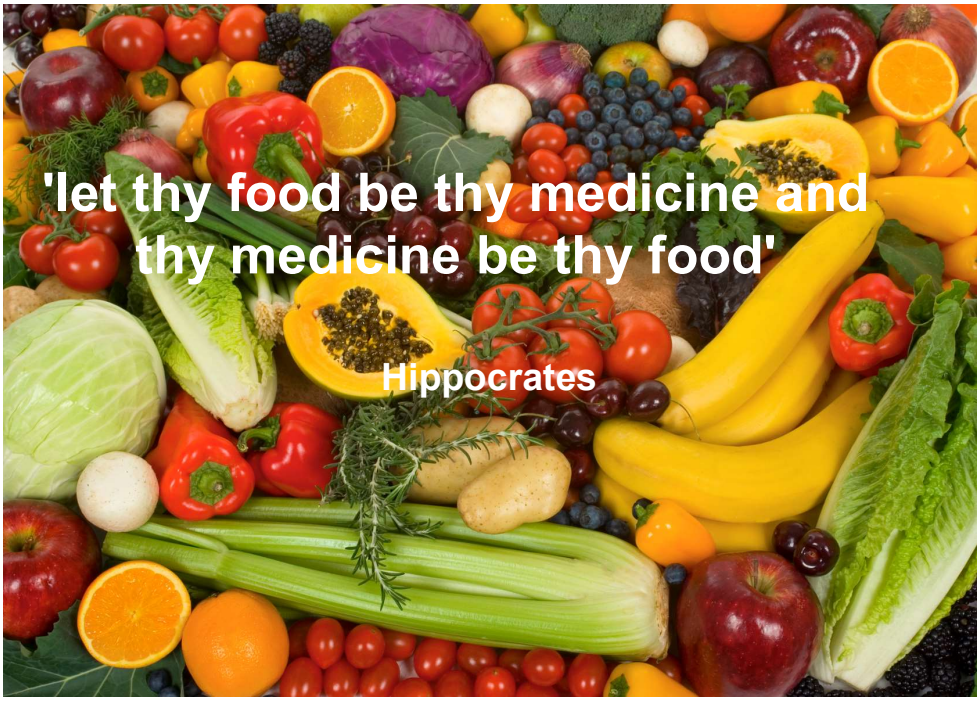
'let thy food be thy medicine and thy medicine be thy food'
Hippocrates

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