

# Gut microbiota: roles in health and diseases and influential factors

CETL04D | 10-min teaching | Jan 16, 2019

Peng Ye, Ph.D. candidate

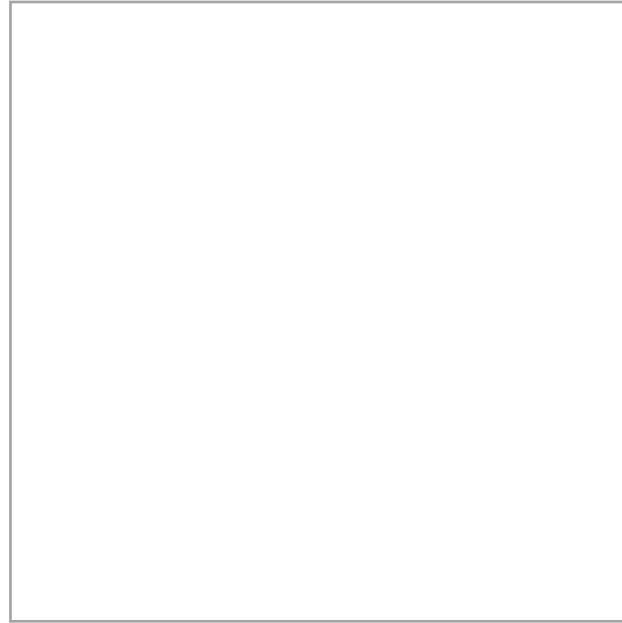
HKU-Pasteur, School of Public Health, LKS Faculty of Medicine

# Learning Outcomes

- List some examples regarding health and diseases that are associated with gut microbiota
- Suggest good practices to have a healthy gut microbiota

# Before we board...

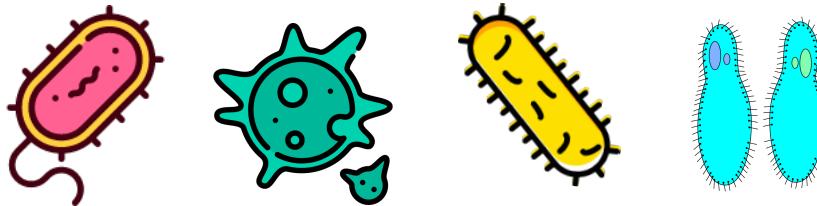
1. Kindly scan the QR code on the right
  
2. Complete the survey on Page 1
  - This is an anonymous survey
  - The 6-digit number is for your own reference
  - Data will be used in the 15-min demonstration only
  
3. Please do NOT turn to next page at this moment



# What is microbiota

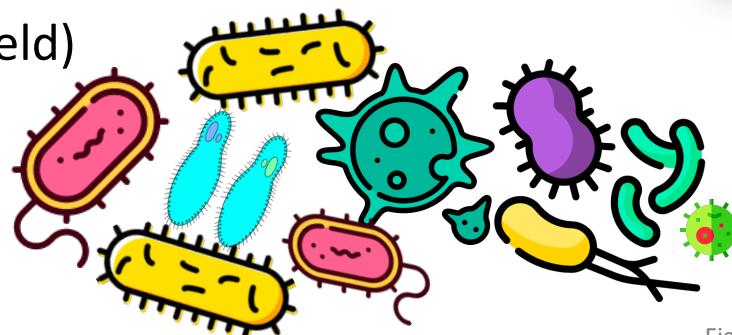
- Microorganisms/microbes

- microscopic (tiny), living organisms
- can be of bacteria, fungi, archaea, protists



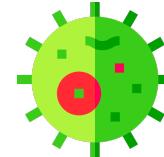
- Microbiota

- microorganisms of a particular site, habitat, or geological period
- Viruses are included (norm in the field)



Viruses?

- not regarded as living
- strictly speaking, **not microorganisms**



Sunday, January 05, 2020

Bloomberg

Business

**China Reports First Death From Mysterious Pneumonia Outbreak**

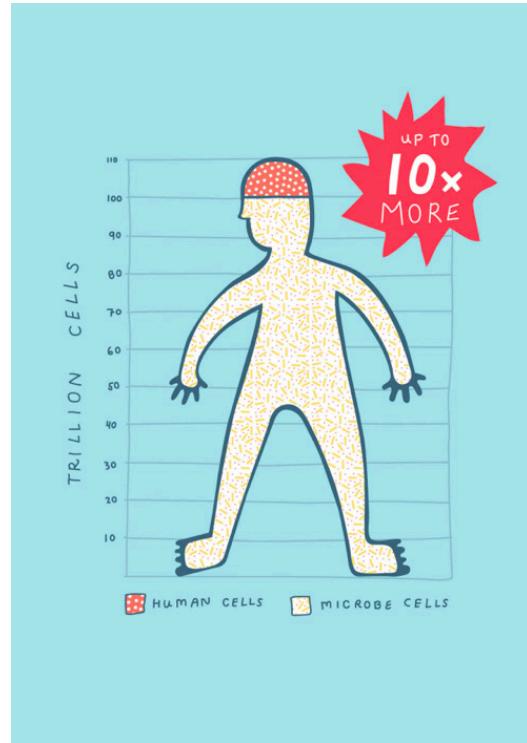
By Linly Lin

January 11, 2020, 9:29 AM GMT+8 January 12, 2020, 8:34 PM GMT+8

World Health Organization

# Can we get rid of microbiota? We can't!

We are only 10-50% human<sup>1, 2</sup>



2015 estimate (Current study)

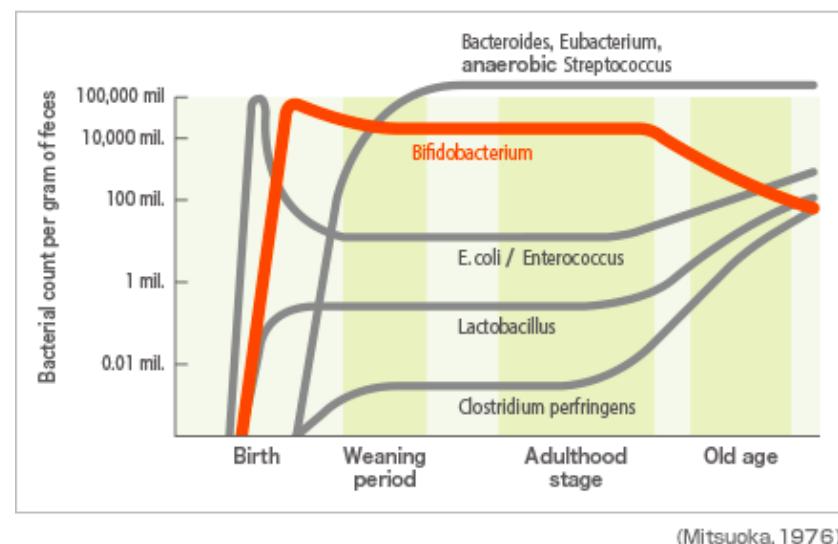
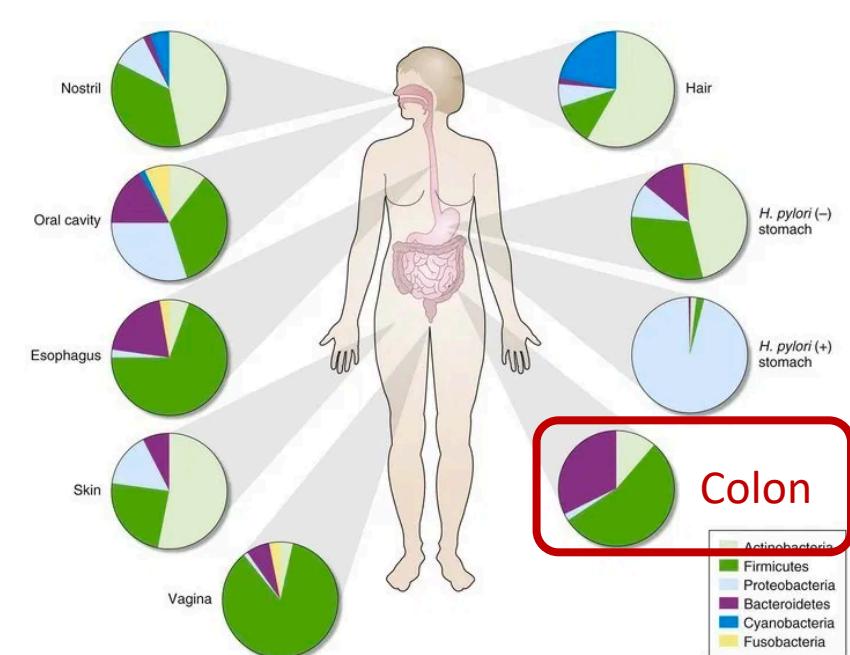
$$\frac{B}{H} = \frac{(V_{colon} \approx 0.4L) \times (n_{bact} \approx 10^{14} \text{ cells/L})}{(V_{blood} \approx 5L) \times (n_{RBC} \approx 5 \times 10^{12} \text{ cells/L})} \approx 1$$
$$\approx 4 \times 10^{13}$$
$$\approx 3 \times 10^{13}$$

The composition of microbiota varies

- by age<sup>3, 4</sup>



- among body sites<sup>5</sup>

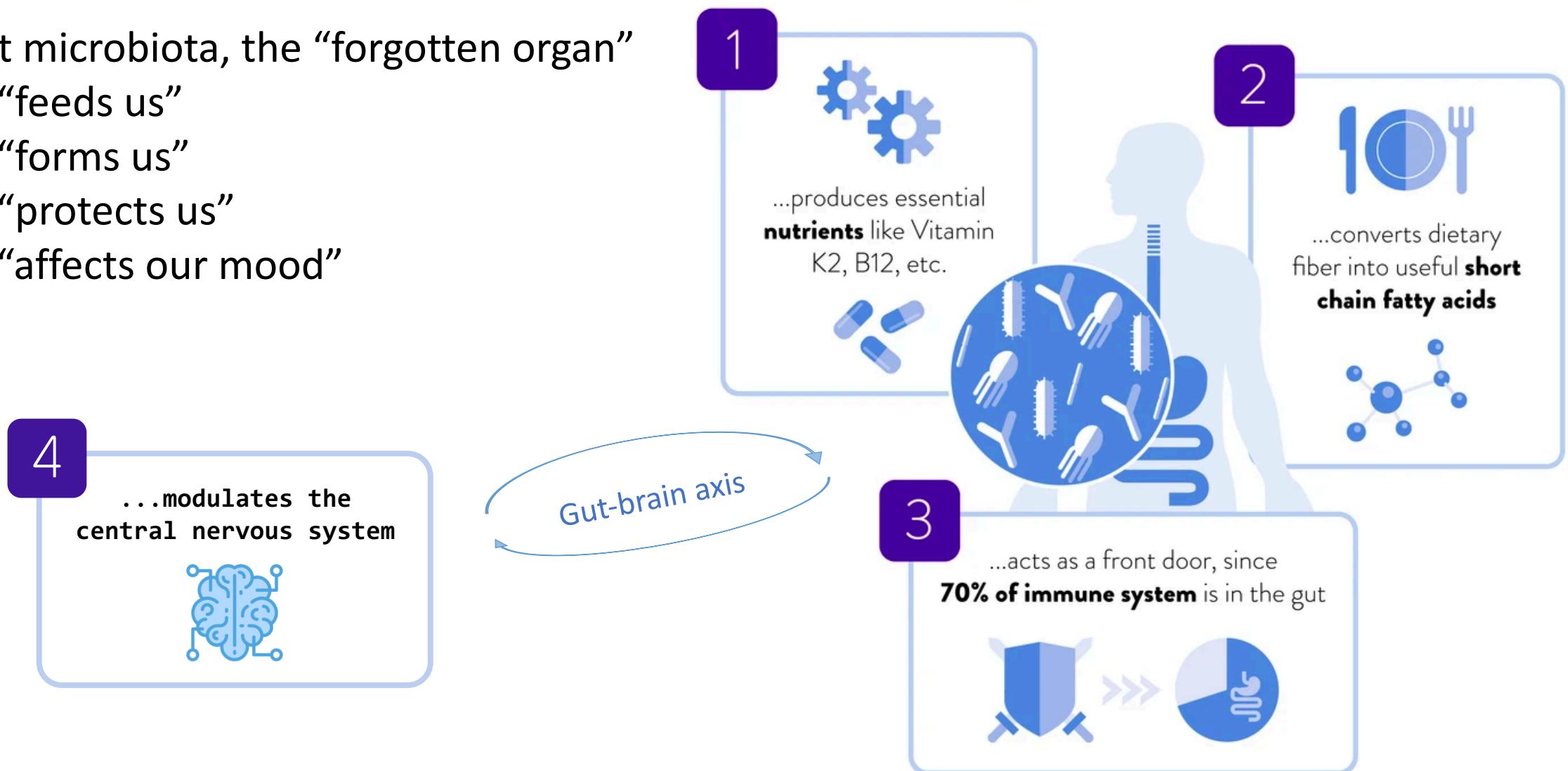


- [1] <https://rhapsodyinwords.com/tag/the-human-microbiome-project/>; [2] PLOS Biology | DOI:10.1371/journal.pbio.1002533; [3] Figures adopted from Your Changing Microbiome. (2014, August 15); [4] <https://www.bb536.jp/english/basic/basic02.html>; [5] <https://oncohemakey.com/the-human-microbiome-of-local-body-sites-and-their-unique-biology/>;

# Can we get rid of microbiota? We can't! And we shouldn't!

Gut microbiota, the “forgotten organ”

- “feeds us”
- “forms us”
- “protects us”
- “affects our mood”



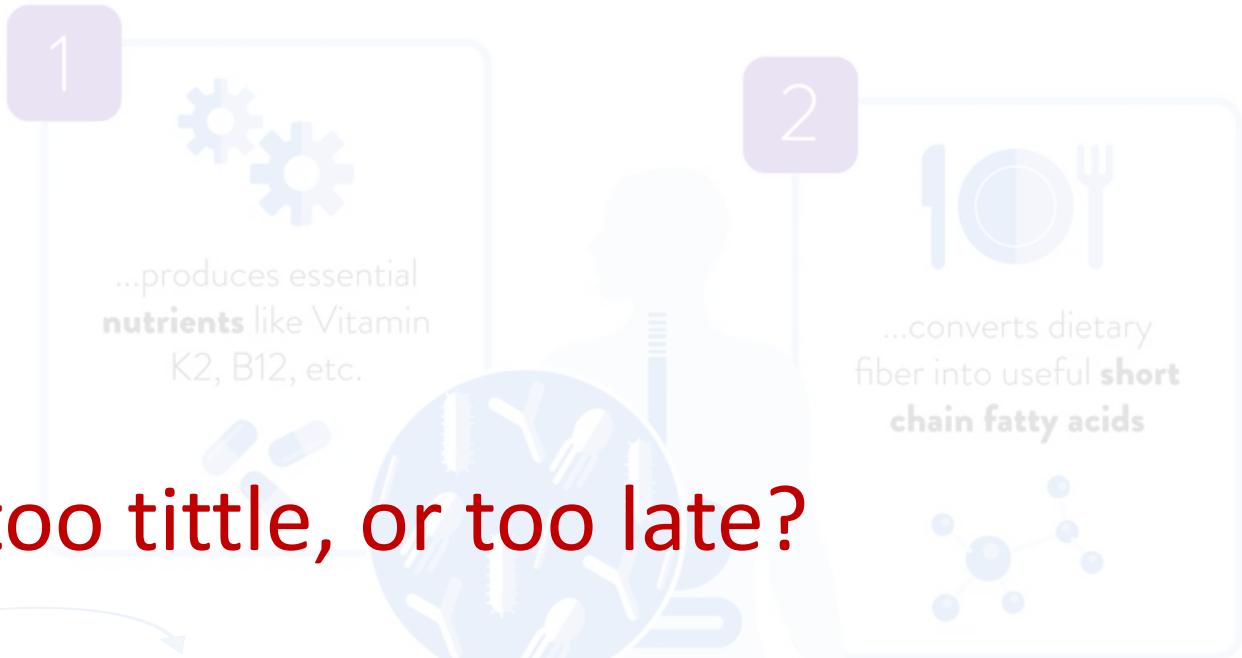
[1] Figure adopted from <https://innovixlabs.com/blogs/insights/3-reasons-why-your-gut-microbiome-is-called-the-forgotten-organ>

[2] [https://www.flaticon.com/free-icon/brain\\_2345027?term=brain&page=1&position=30](https://www.flaticon.com/free-icon/brain_2345027?term=brain&page=1&position=30); [3] doi:10.1136/archdischild-2016-311643

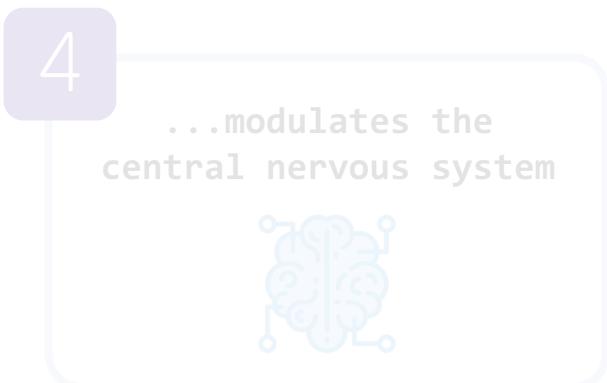
# What if the gut microbiota is unhealthy?

Gut microbiota, the “forgotten organ”

- “feeds us”
- “forms us”
- “protects us”
- “affects our mood”



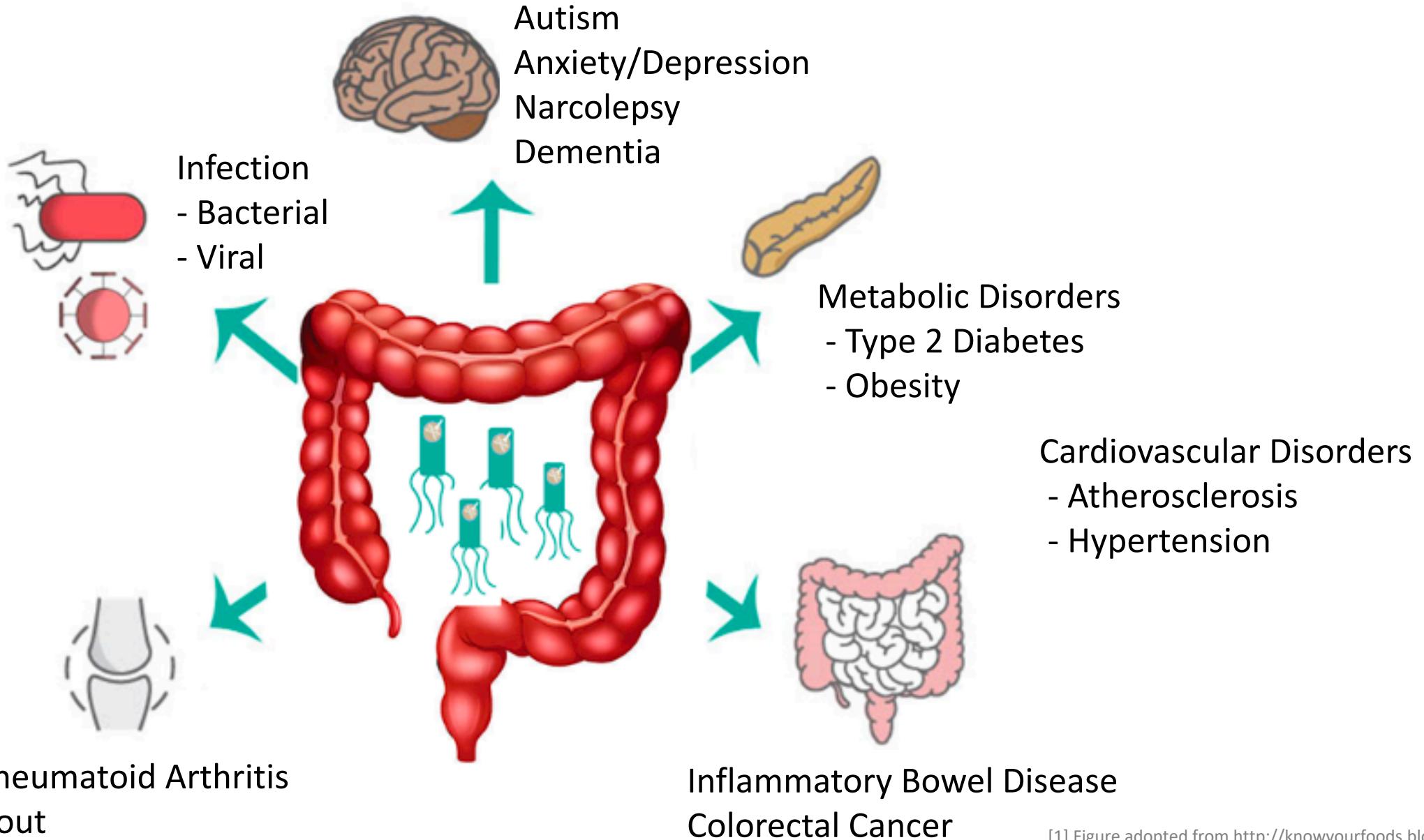
**Say, too much, too little, or too late?**



[1] Figure adopted from <https://innovixlabs.com/blogs/insights/3-reasons-why-your-gut-microbiome-is-called-the-forgotten-organ>

[2] [https://www.flaticon.com/free-icon/brain\\_2345027?term=brain&page=1&position=30](https://www.flaticon.com/free-icon/brain_2345027?term=brain&page=1&position=30); [3] doi:10.1136/archdischild-2016-311643

# What if the gut microbiota is unhealthy? We get diseases!

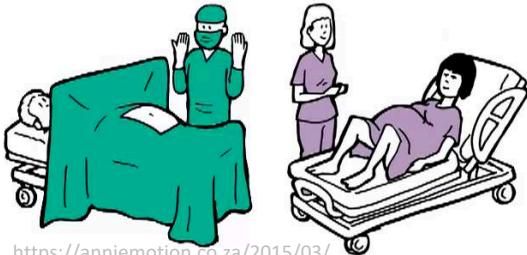


[1] Figure adopted from <http://knowyourfoods.blog/>

[2] doi:10.1136/archdischild-2016-311643

# Influential factors on gut microbiota

Planned C-section    Planned Vaginal Birth



<https://anniemotion.co.za/2015/03/27/vj-delivery-vs-c-section-delivery/>



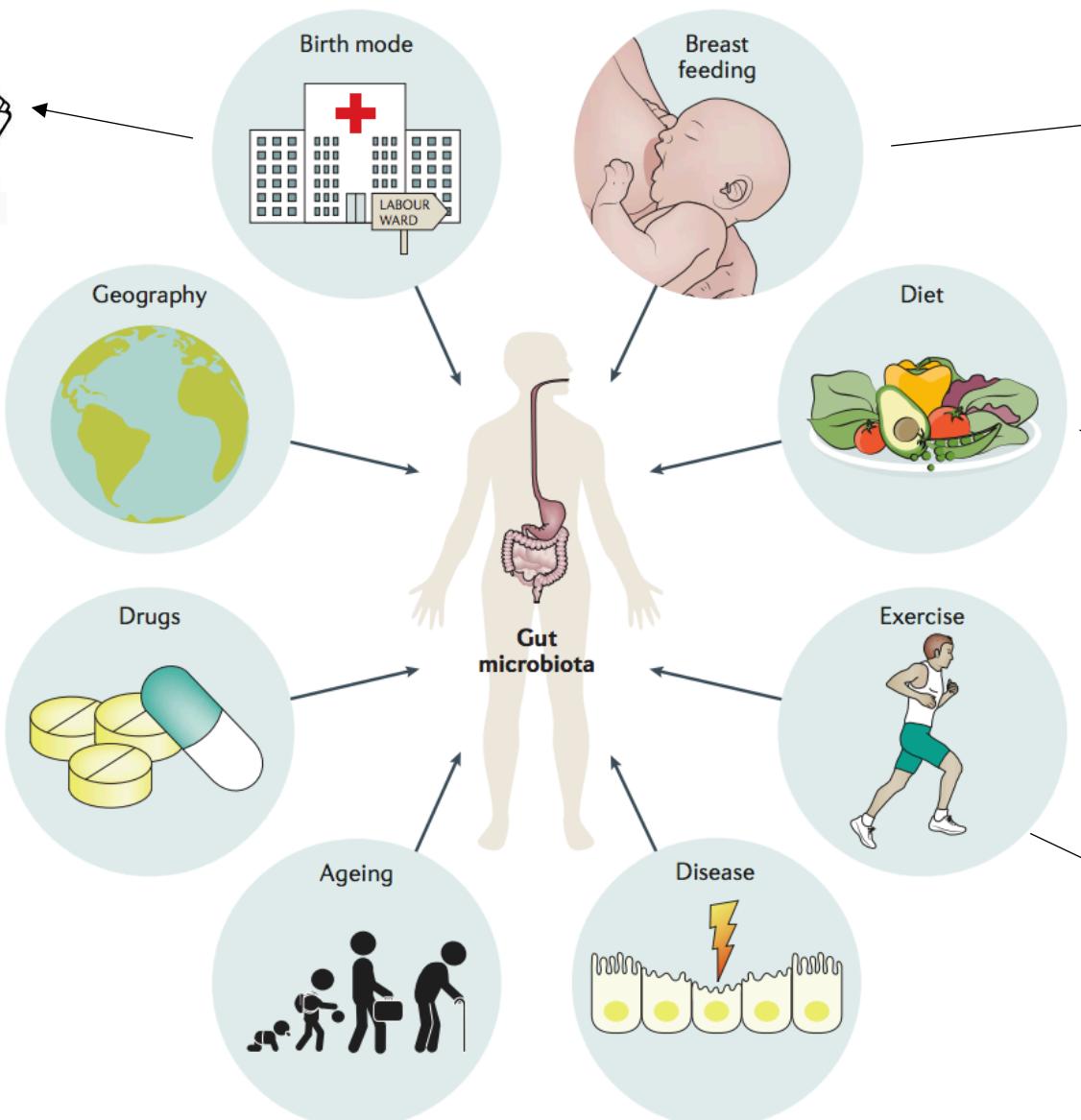
<http://www.coolbabypid.com/breastfeeding-vs-bottle-feeding/>



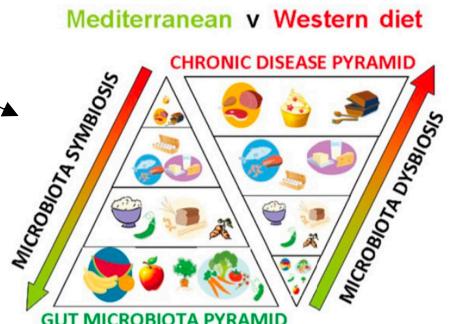
<https://www.pinterest.com/pin/109775309638216176/>



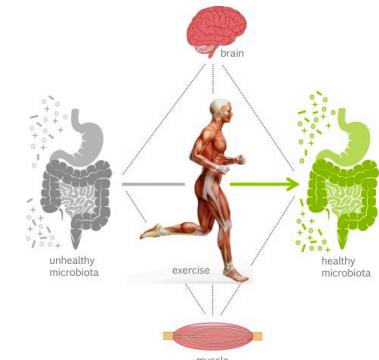
<https://autodidactauthor.files.wordpress.com/2014/09/antibiotic-bombs1.png>



<doi:10.1038/nrgastro.2017.29>

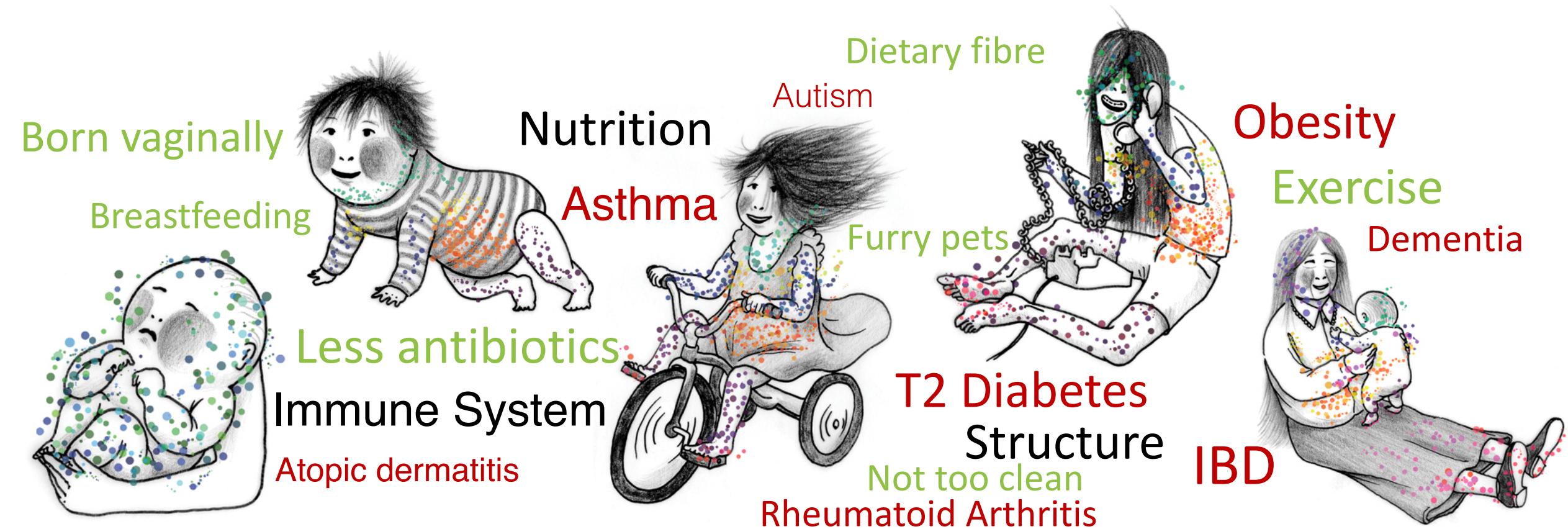


<https://www.gutmicrobiotaforhealth.com/en/conserving-restoring-human-gut-microbiome-increasing-consumption-dietary-fibre/>



<https://doi.org/10.1016/j.dld.2017.11.016>

# Summary

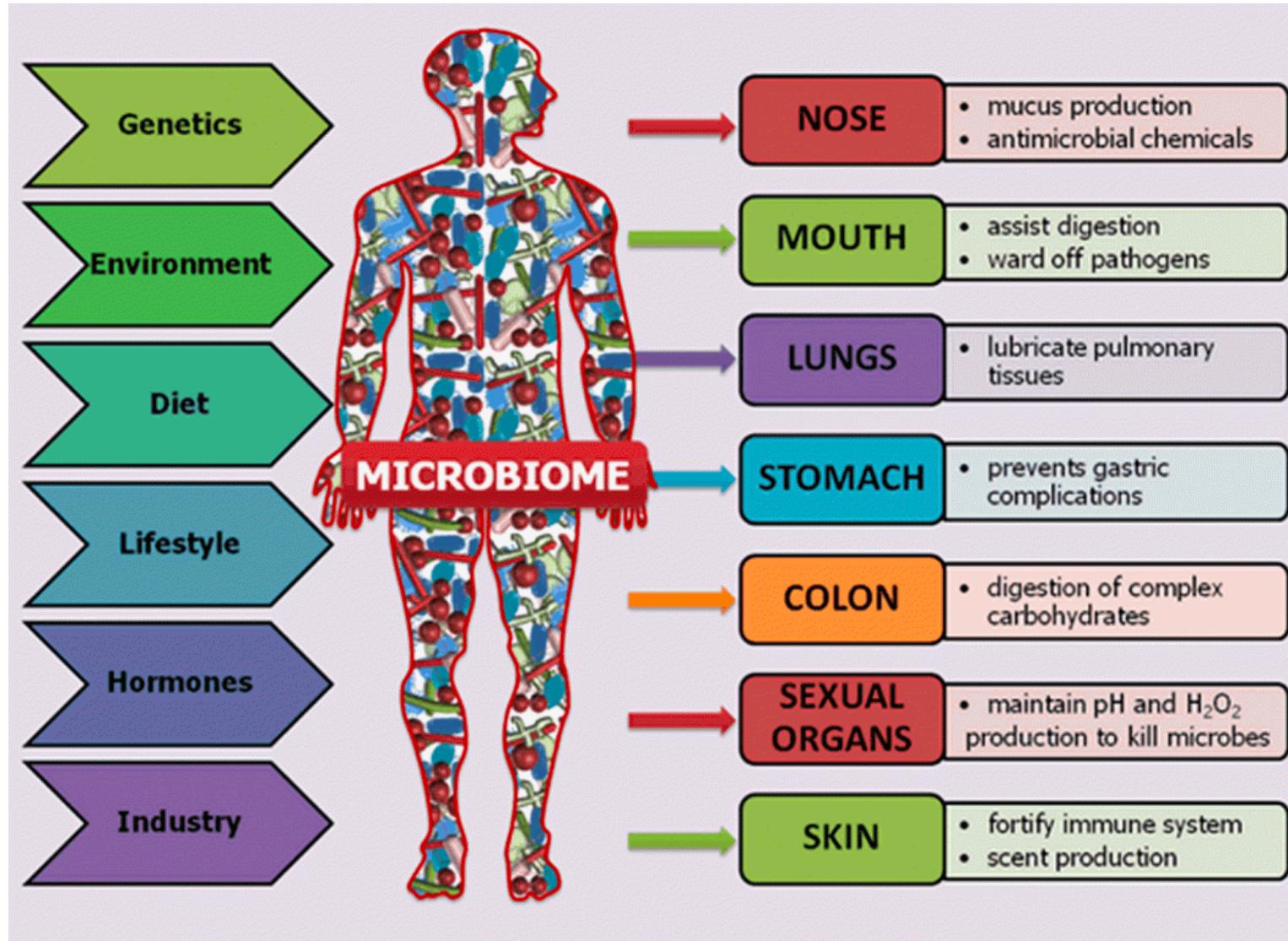


**Thank you!**  
**Any questions you may have?**

Contact: [pengye@connect.hku.hk](mailto:pengye@connect.hku.hk)



# Supplementary Slide 1: major function of microbiota in different body sites



## Supplementary Slide 2: Gut-brain axis

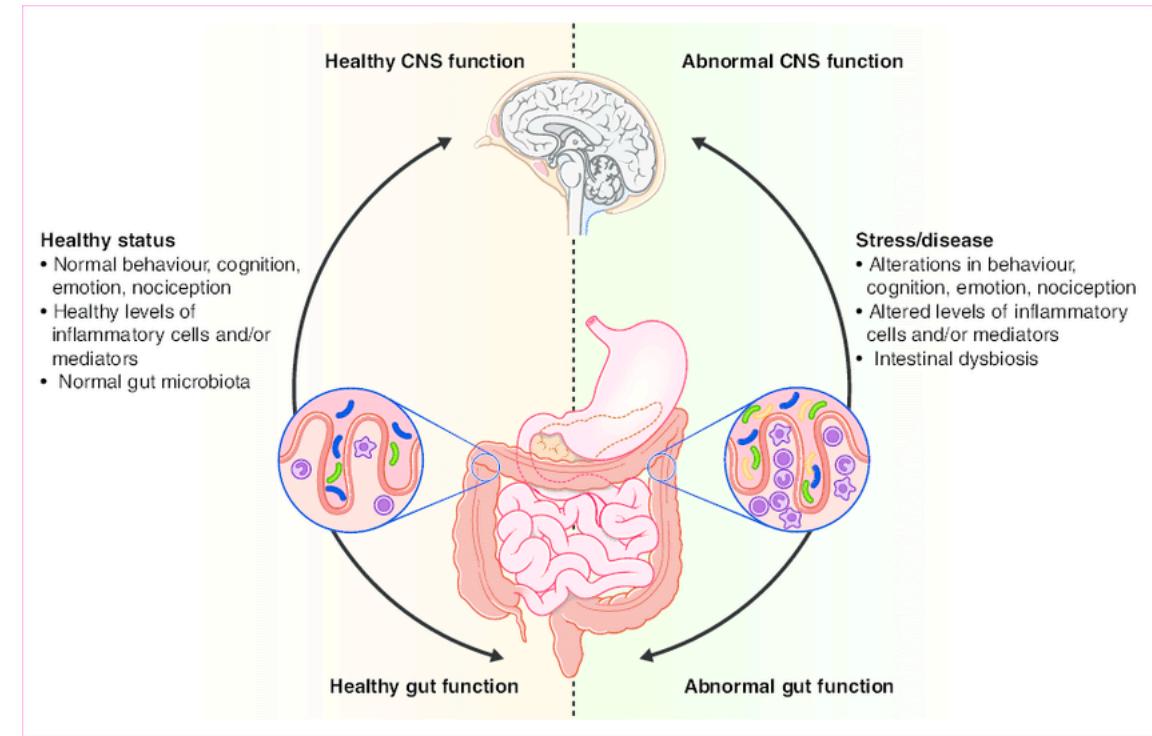
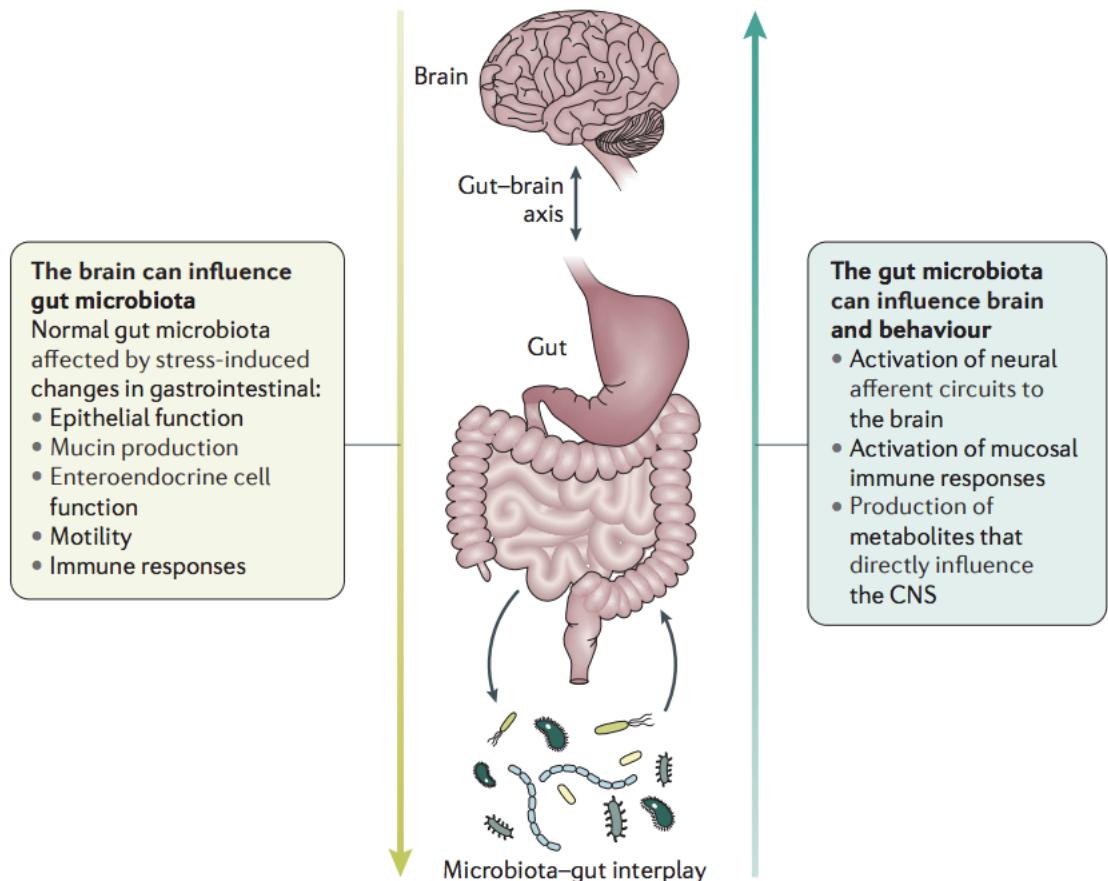


Figure 2 | **The microbiome-gut-brain axis.** A bidirectional interaction occurs between gut microbiota, the gut (including its immune and neural networks, as well as the gut barrier) and the brain. CNS, central nervous system. Modified, with permission, from Elsevier © Collins, S. M. & Bercik P. *Gastroenterology* 136, 2003–2014 (2009).

- [1] Quigley, E. M. M. (2017). Gut microbiome as a clinical tool in gastrointestinal disease management: are we there yet? *Nature Reviews Gastroenterology & Hepatology*, 14(5), 315–320. doi:10.1038/nrgastro.2017.29
- [2] [https://www.researchgate.net/figure/Impact-of-the-gut-microbiota-on-the-gut-brain-axis-in-health-and-disease-A-stable-gut\\_fig3\\_258198236](https://www.researchgate.net/figure/Impact-of-the-gut-microbiota-on-the-gut-brain-axis-in-health-and-disease-A-stable-gut_fig3_258198236)

# Supplementary Slide 3: Gut microbiota-associated human diseases (Source 1)

Disease categories	Specific diseases	Associated dysbiotic features	Reference	Type-2 diabetes		
Immune-mediated/autoimmune diseases	inflammatory bowel disease (IBD)  Irritable bowel syndrome (IBS)  Celiac disease  Systemic lupus erythematosus (SLE)	<ul style="list-style-type: none"> <li>Increase in virulent gut microbes (<i>Enterobacteriaceae</i>, <i>Bacteroides fragilis</i>) and mucolytic <i>Ruminococcus</i> sp.</li> <li>Decrease in butyrate-producing Firmicutes (such as <i>Faecalibacterium prausnitzii</i>, <i>Roseburia hominis</i>)</li> <li>Increase in <i>Escherichia coli</i></li> <li>Decrease in <i>Clostridium leptum</i> group of bacteria and <i>Bifidobacterium</i>.</li> <li>Decrease in bile acid biotransformation</li> <li>Increase in <i>Bacteroides-Prevotella</i> group</li> <li>Decrease in <i>Bifidobacterium</i></li> <li>Varying observation (decrease or no change) in <i>Clostridium histolyticum</i>, <i>C. lituseburense</i>, and <i>Faecalibacterium prausnitzii</i></li> <li>Alteration in SCFAs composition, but overall increase in total SCFA</li> <li>Increase in <i>Blautia</i> sp. and Gram-negative bacteria such as <i>Proteobacteria</i>.</li> <li>Decrease in gut microbiota diversity, <i>Odoribacter</i> sp., <i>Alistipes</i> sp.</li> <li>Increase in serum endotoxin</li> <li>Increase in <i>Bacteroidetes</i></li> <li>Decrease in <i>Actinobacteria</i>, Firmicutes, and Firmicutes/Bacteroidetes ratio</li> <li>Increase in <i>Prevotella copri</i> and decrease in <i>Bacteroides</i> sp. In new-onset RA</li> <li>Increase in microbiota diversity of <i>Lactobacillus</i> genus in early RA</li> <li>Increase in fecal burden of <i>Clostridium difficile</i>, and <i>C. difficile/Bifidobacteria</i> ratio</li> <li>Increase in <i>Firmicutes</i>, <i>Actinobacter</i></li> <li>Varying observation (decrease, no change, increase) in <i>Bacteroidetes</i></li> <li>Increase in glycoside hydrolase and SCFAs (butyrate and acetate)</li> </ul>	Sokol et al., 2008; Png et al., 2010; Willing et al., 2010; Machiels et al., 2014  Duboc et al., 2012  Tjellström et al., 2005; Nadal et al., 2007; De Palma et al., 2010  Shi et al., 2014; Luo et al., 2018  Murri et al., 2013  Liu et al., 2013; Scher et al., 2013  Kalliomäki et al., 2001  Turnbaugh et al., 2006, 2009a; Kollada et al., 2017	Hypertension  Atherosclerosis  Cancer  Neuropathy/atrial fibrillation  Alzheimer's disease  Depression  Parkinson's Disease  Infectious disease  Uremic disease	<ul style="list-style-type: none"> <li>Increase in <i>Lactobacillus</i></li> <li>Decrease in <i>Clostridium coccoides</i>, <i>Atopobium</i> cluster, and <i>Prevotella</i></li> <li>Decrease in butyrate biosynthesis</li> <li>Increase in the Firmicutes/Bacteroidetes ratio, lactate-producer</li> <li>Decrease in microbiota diversity, acetate- and butyrate-producers</li> <li>Increase in metabolites TMAO, endotoxin level (risk factor for early atherosclerosis)</li> <li>Increase in enterotoxigenic <i>Bacteroides fragilis</i>, and pathogens <i>Fusobacterium</i> and <i>Campylobacter</i> sp.</li> <li>Decrease in butyrate-producer (<i>Faecalibacterium</i> and <i>Roseburia</i>)</li> <li>Increase in <i>Clostridium</i> sp., Bacteroidetes, <i>Lactobacillus</i>, <i>Desulfovibrio</i></li> <li>Decrease in <i>Bifidobacteria</i></li> <li>Possible connection between gut microbiota-synthesized amyloids, LPS, <math>\gamma</math>-aminobutyric acid (GABA – major inhibitory neurotransmitter), and the increased permeability of gut barrier and blood brain barrier with age</li> <li>Increase in genus <i>Eggerthella</i>, <i>Holdemania</i>, <i>Gelria</i>, <i>Turicibacter</i>, <i>Paraprevotella</i>, <i>Anaerofilum</i></li> <li>Decrease in gut microbiota diversity, <i>Prevotella</i> and <i>Dialister</i></li> <li>Increase in anti-inflammatory butyrate-producers from genus <i>Blautia</i>, <i>Coprococcus</i>, and <i>Roseburia</i> in patient fecal sample, pro-inflammatory <i>Proteobacteria</i> in patient mucosa</li> <li>Increased gene expression in LPS biosynthesis and microbial type III secretion system</li> <li>Increase in <i>Clostridium difficile</i>;</li> <li>Decrease in gut microbiota diversity and secondary bile acids-producing <i>Clostridium scindens</i></li> <li>Increase in <i>Firmicutes</i>, <i>Proteobacteria</i>, and <i>Actinobacteria</i></li> <li>Decrease in <i>Lactobacilli</i></li> </ul>	<p>Qin et al., 2012; Sato et al., 2014</p> <p>Yang et al., 2015</p> <p>Wiedermann et al., 1999; Koeth et al., 2013</p> <p>Wang et al., 2012; Wu et al., 2013</p> <p>Song et al., 2004; Adams et al., 2011</p> <p>Pistollato et al., 2016</p> <p>Kelly et al., 2016</p> <p>Keshavarzian et al., 2015</p> <p>Theriot et al., 2014</p> <p>Vaziri et al., 2013</p>
Metabolic disorders/cardiovascular disorders	Obesity					

# Supplementary Slide 4: Gut microbiota-associated human diseases (Source 2)

**Table 1.** Summary of diet-microbiota interactions in health and disease.

Healthy Microbiota	Gut Dysbiosis	Other Cause/Consequence
High dietary fiber intake [115]	Western diet; low core diversity [10,83]	High in choline/fat/added sugar [105,117]
Plant foods low in choline [151]	High [TMAO] in blood [134]	Arterial plaque formation [135]
Fruits and vegetables; prebiotic-containing foods [4]	Low fiber intake/low FODMAP carbs [244]	Beer, bread, sugar/artificially-sweetened beverages [120,122]
High $\alpha$ species diversity; butyrate-producing [4,105,120]	Low short-chain fatty acid fermentation [100]	Intestinal inflammation [25,117]
Anti-inflammatory omega-3 [217]	Diet high in omega-6 fatty acids	Pro-inflammatory [149]
Lean body mass, increased lipolysis [84]	Obesity, vagal remodeling, increased energy harvest [85,105]	Increased appetite/lipogenesis [103]
High <i>Prevotella</i> /low <i>Bacteroides</i> ; abundance of <i>A. muciniphila</i> [12,14,91]	Abundance of <i>Ruminococcus</i> [16,105]	High Firmicutes:Bacteroidetes ratio [85,105]
Glucose and lipid homeostasis [100]	Insulin resistance, bacterial encroachment [76,106,271]	Cardiovascular disease [111,151]
Beneficial bacteria/probiotics: <i>Bifidobacterium</i> , <i>Lactobacillus</i> [192,206]	Oxidative stress; facultative anaerobes; <i>E. coli</i> [38]	Broad-spectrum antibiotics [22,39,287]; medication dysbiosis [290]
Gut-brain interactions [78]	Mental health issues or visceral pain [72,296]	Leaky gut, plasma endotoxin, psychological stress; emulsifiers [54,272]
Regular intestinal motility [222,259]	Structural or functional bowel disorders [22,50]	Colorectal cancer [3]
Healthy fecal biomarkers [53]	Need butyrate/inulin supplementation [81,104,213]	Potential for fecal transplant [73,76]
Intermittent fasting; adipose beiging [273]	Excess starch/sugar consumption [120]	<i>Candida</i> overgrowth; gluten sensitivity [241,256]