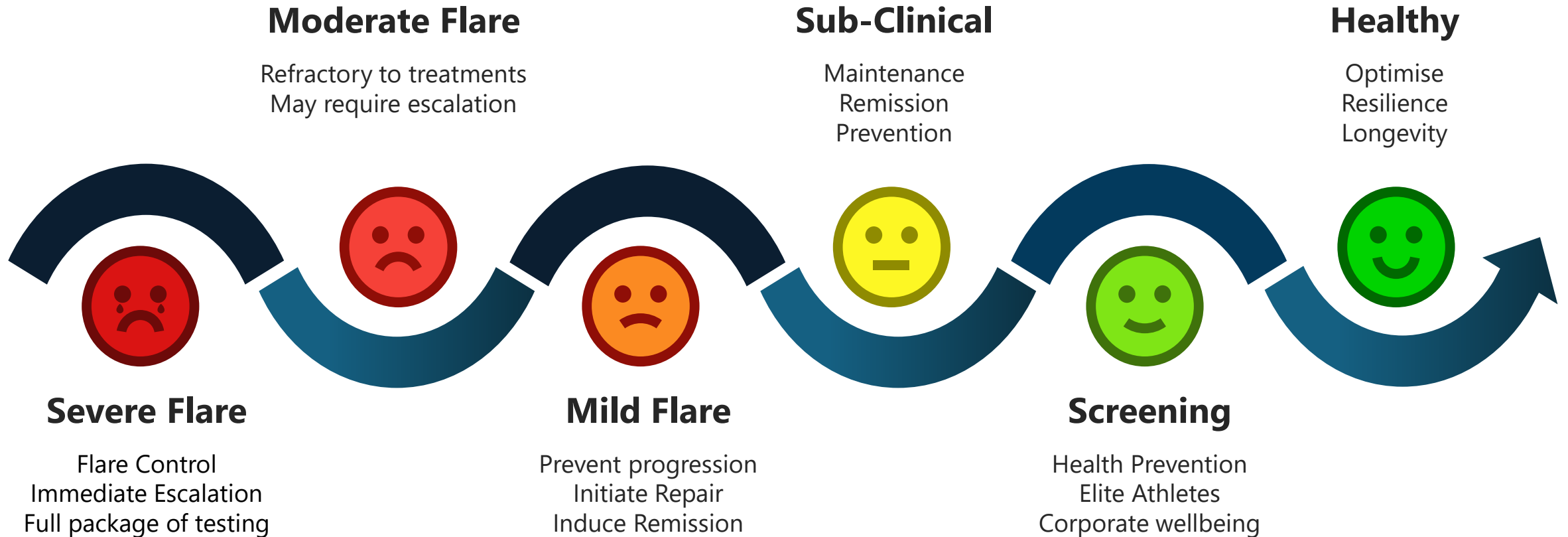


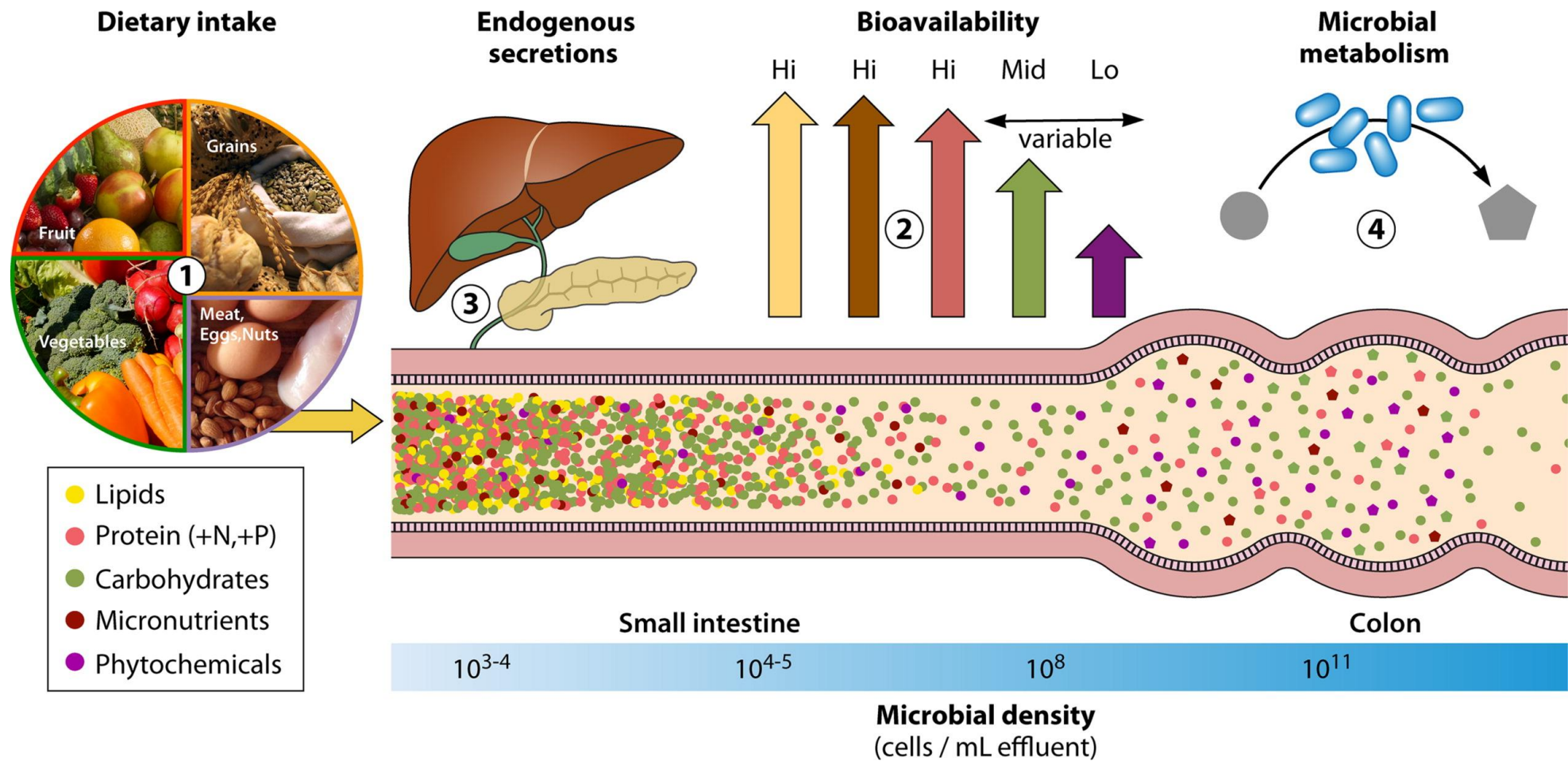
# SIBO Uncovered: The Evidence Behind Diagnosis, Testing and Treatment

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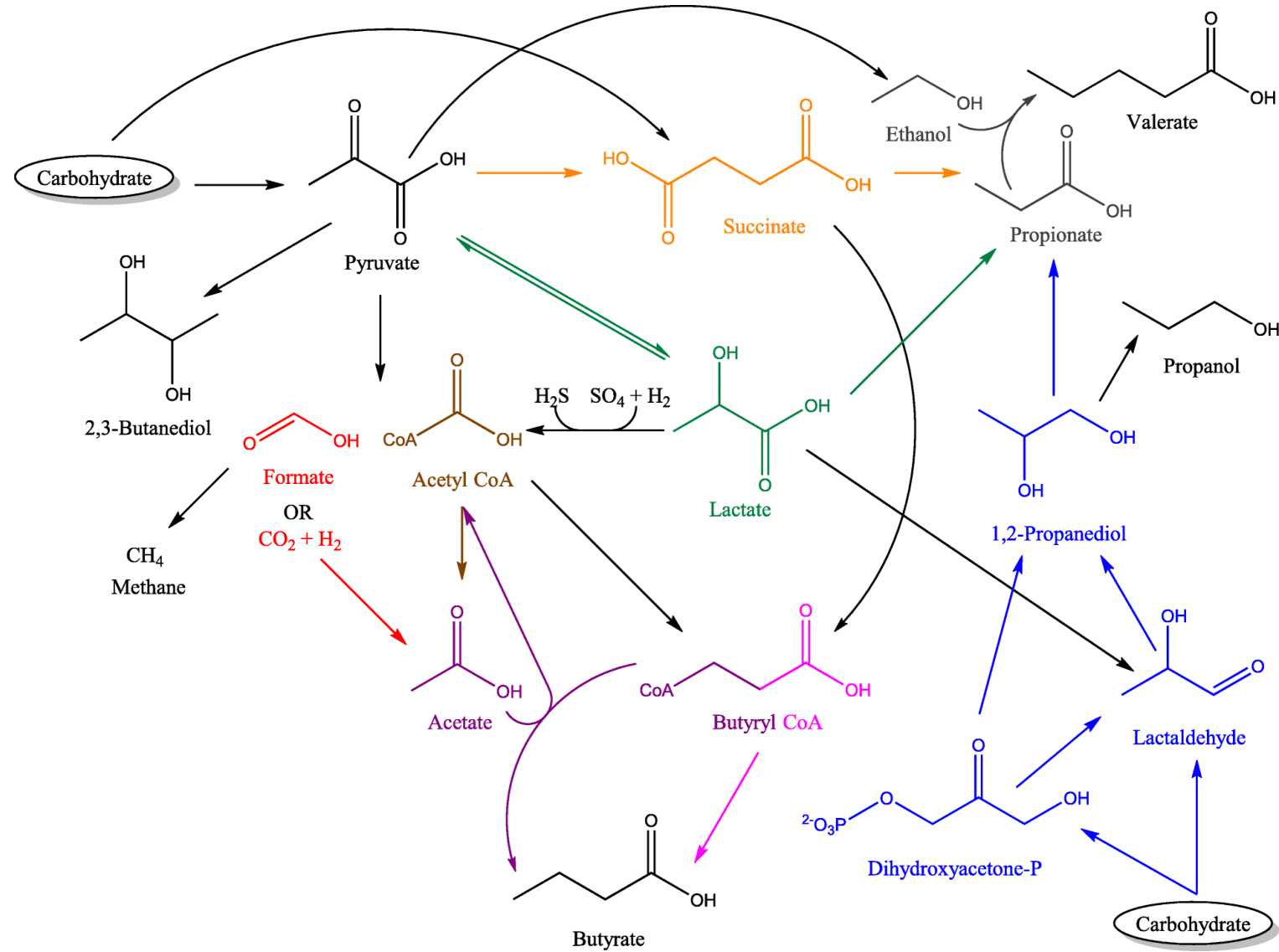
**Dr Anthony R. Hobson PhD, Clinical Director,  
Clinical GI Scientist, Functional Gut Clinic, UK**

# The Digestive Health Continuum – Clinical Spectrum





# Microbial metabolism



Adapted from Oliphant & Allen-Vercoe. Microbiome. 2025

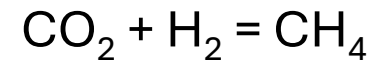
# Fermentation

Hydrogen (H<sub>2</sub>) and Carbon Dioxide (CO<sub>2</sub>) are products of **saccharolytic** fermentation

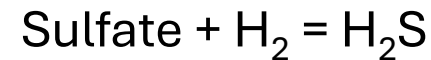
Methane (CH<sub>4</sub>) and Hydrogen Sulphide (H<sub>2</sub>S) are **not** saccharolytic

This is a **hydrogenotrophic** process

Methanogens e.g. *Methanobrevibacter*



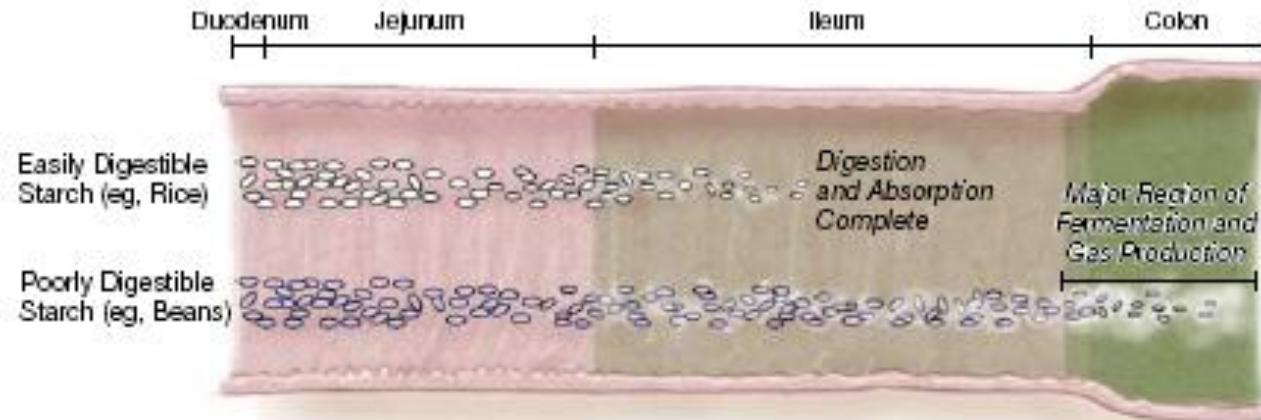
Sulfate-reducing bacteria e.g. *Desulfovibrio*



Hydrogenotrophy improves metabolism in the colon by acting as a **hydrogen sink**

# SIBO = premature fermentation

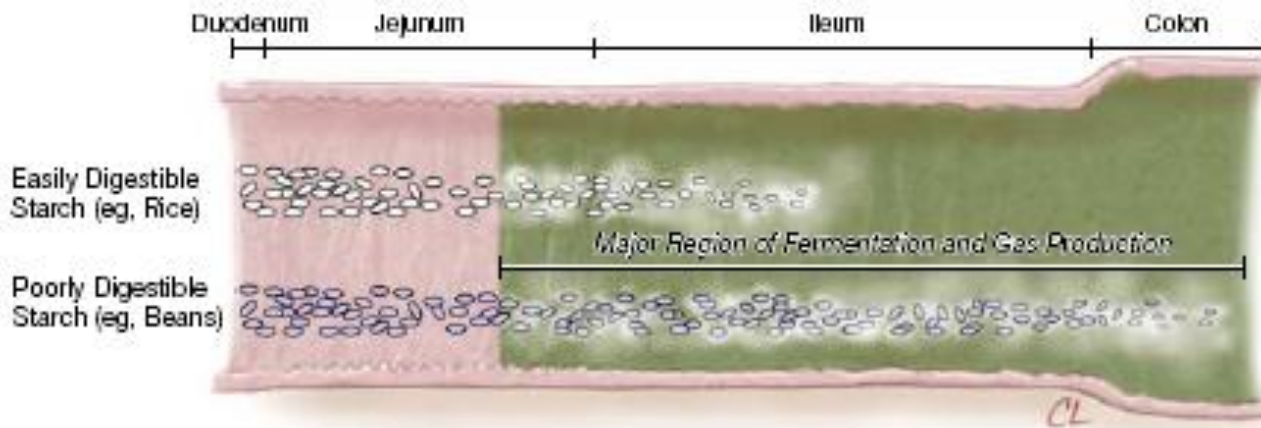
**A** Normal Distribution of Intestinal Bacterial Flora



Bacterial Concentration, organisms/mL



**B** Small Intestinal Bacterial Overgrowth



# Bloating is the a cardinal of symptom of SIBO but does not mean SIBO

| Table 1. Differential diagnosis for bloating and distension                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nongastrointestinal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Gastrointestinal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DGBIs                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"><li>• Food (flatulogenic diet, FODMAPs [fermentable oligosaccharides, disaccharides, monosaccharides, and polyols], insoluble fibers, osmotic solutes [xylitol], and salt)</li><li>• Medications (lactulose, opioids, and nonsteroidal anti-inflammatory drugs)</li><li>• Obesity</li><li>• Gynecologic malignancy</li><li>• Hypothyroidism</li><li>• Premenstrual syndrome</li><li>• Endometriosis</li><li>• Connective tissue disorders (Ehlers-Danlos)</li><li>• Postural orthostatic tachycardia syndrome</li><li>• Scoliosis</li></ul> | <ul style="list-style-type: none"><li>• Small intestinal bacterial overgrowth</li><li>• Lactose, fructose, or other carbohydrate malabsorption/intolerances</li><li>• Celiac disease</li><li>• Pancreatic insufficiency</li><li>• Prior gastrointestinal surgery (fundoplication and bariatric surgery)</li><li>• Gastric outlet obstruction</li><li>• Gastroparesis</li><li>• Ascites</li><li>• Gastrointestinal malignancy</li><li>• Small bowel dysmotility</li><li>• Small intestine diverticulosis</li><li>• Mechanical obstruction</li><li>• Chronic intestinal pseudo-obstruction</li><li>• <i>Helicobacter pylori</i> and chronic enteric infections (e.g., giardiasis)</li></ul> | <ul style="list-style-type: none"><li>• IBS</li><li>• Chronic idiopathic constipation</li><li>• Opioid-induced constipation</li><li>• Dyssynergic defecation/pelvic floor dysfunction</li><li>• FD</li><li>• Aerophagia</li><li>• Functional bloating and distension</li></ul> |
| DGBI, disorders of the gut-brain interaction; FD, functional dyspepsia; FODMAP, low fermentable oligosaccharides, disaccharides, monosaccharides and polyols diet; IBS, irritable bowel syndrome.                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                |

# Symptoms of SIBO

HMBT-Q Study - Can symptoms and medical history predict SIBO:

- Combination of abdominal pain, belching, regurgitation
- Abdominal pain or discomfort immediately after eating
- Daily abdominal pain AND predominant diarrhoea
- Skin conditions e.g. eczema, rosacea

# Symptoms of SIBO

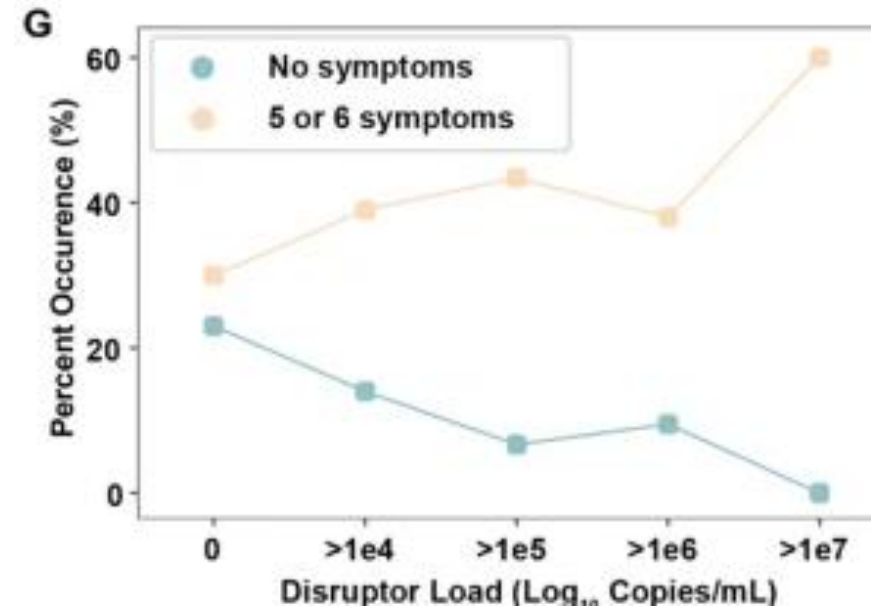
- 1: Bloating
- 2: Excess gas
- 3: Diarrhoea
- 4: Urgency
- 5: Constipation
- 6: Incomplete emptying

**60% of people with 5 symptoms** had  $>1e7$  disruptor taxa

Adapted from Barlow et al. Microbiome. 2021

**0% of people with 0 symptoms** had  $>1e7$  disruptor taxa

Disruptor taxa: *Klebsiella*, *Escherichia*, *Enterococcus*, and *Clostridium*



# Risk factors for SIBO

## 1. Decreased stomach acid

- Long-term PPI use, Autoimmune gastritis/pernicious anaemia

## 2. Motility issues

- Connective tissue disorders (Scleroderma, Ehlers Danlos syndrome, etc), diabetic neuropathy, defective migrating motor complex (MMC), drugs (opioids, GLP1s)

## 3. Structural

- Problems with the ileo-caecal valve, Crohn's, celiac, pseudo-obstructions, fistulas, adhesions, diverticula, bariatric surgery, radiotherapy

## 4. Autoimmune conditions

- Hashimoto's, Scleroderma, Sjogren's, AIG

Khurmatullina. J Clin Med. 2025  
Damianos. Minerva Gastro. 2026  
Barlow. Curr Opin Gastro. 2025  
Wei. J Clin Endo Metab. 2026

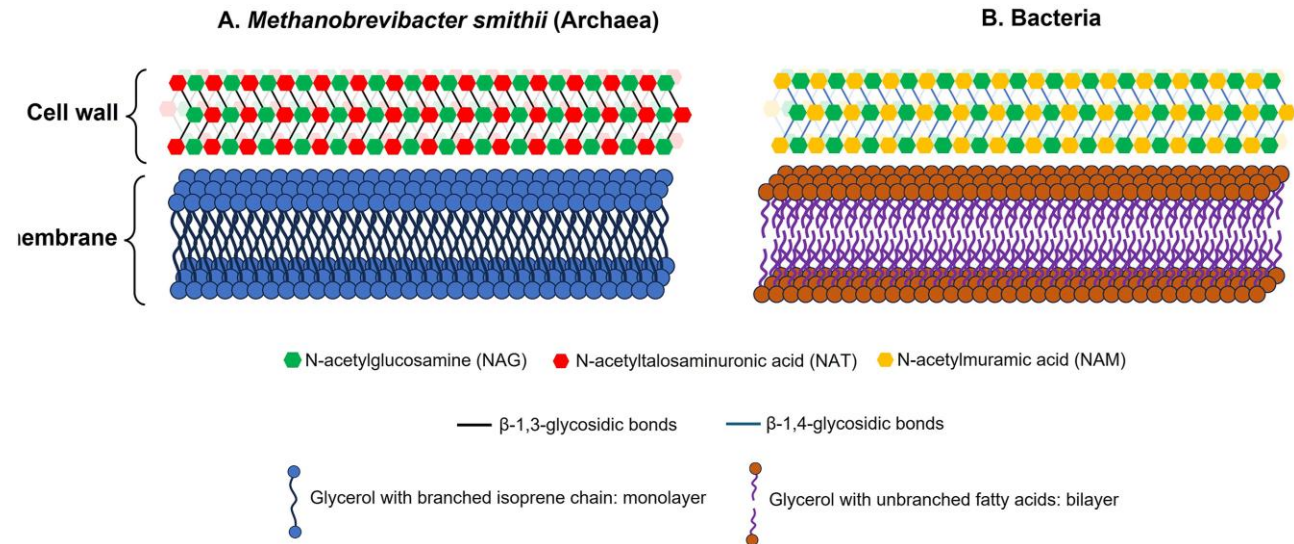
# Intestinal methanogen overgrowth

Methanogens are mostly archaea – not bacteria

*Methanobrevibacter smithii* predominant methanogen in human gut

May overgrow in small intestine or colon

**IMO** not SIBO/SIMO



Adapted from Malat. Helyion. 2024

# Symptoms and risk factors of IMO

Constipation

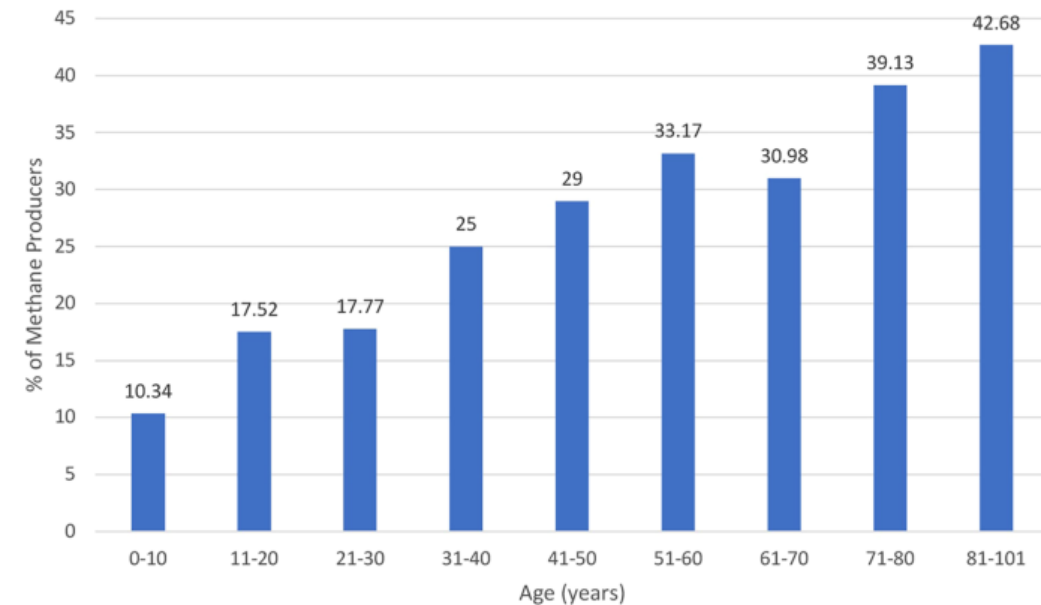
Stools that float

Protects against IBD

Increasing prevalence with age

Anorexia nervosa and Obesity

Parkinson's disease



Increasing prevalence of methane production with age (Takakura. Sci Rep. 2020)

# Hydrogen sulphide



H<sub>2</sub> and CH<sub>4</sub> exclusively produced by microbes

Endogenous H<sub>2</sub>S is a signalling molecule produced by endothelial cells, hepatocytes, pancreatic beta cells, enterocytes, and neurons

Roles include vasodilation, memory, angiogenesis, anticoagulation, immune response, insulin secretion, motility, bone metabolism, oxygen sensing, neurotransmission, erection, and pain sensation

Toxic to colonocytes (and humans) in large amounts

# Intestinal sulphide overproduction

Diarrhoea, Urgency, Acid Reflux

Greater overall symptom severity

IBD

IBS-D

Colorectal cancer

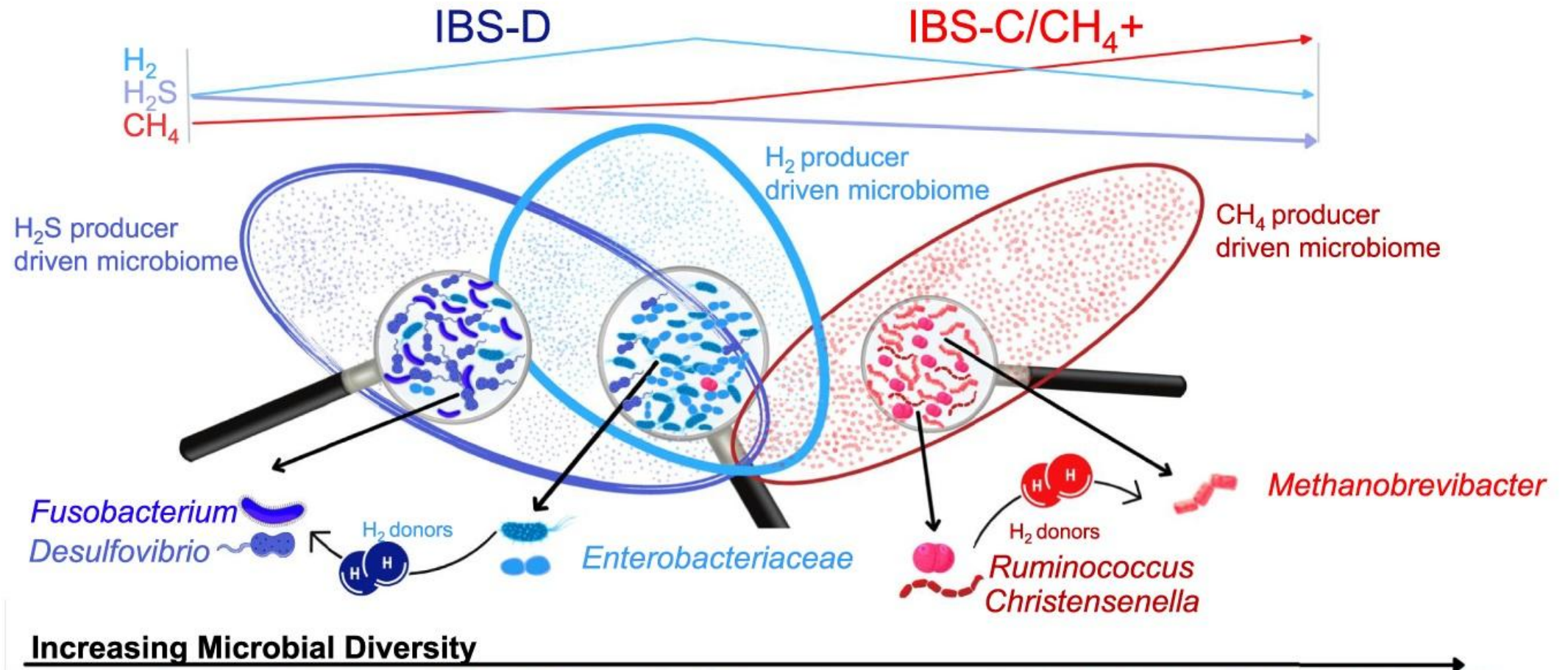
Key players:

**Sulfate reducers:** *Desulfovibrio*

**Sulfite reducers:** *Bilophila wadsworthia*, *Salmonella*, *Pseudomonas*

**Cysteine desulfhydrase:** *Fusobacterium*

# Distinct Microtypes Drive IBS Subtypes



# Diagnosis of SIBO, IMO & ISO

## Duodenal/Jejunal aspirate

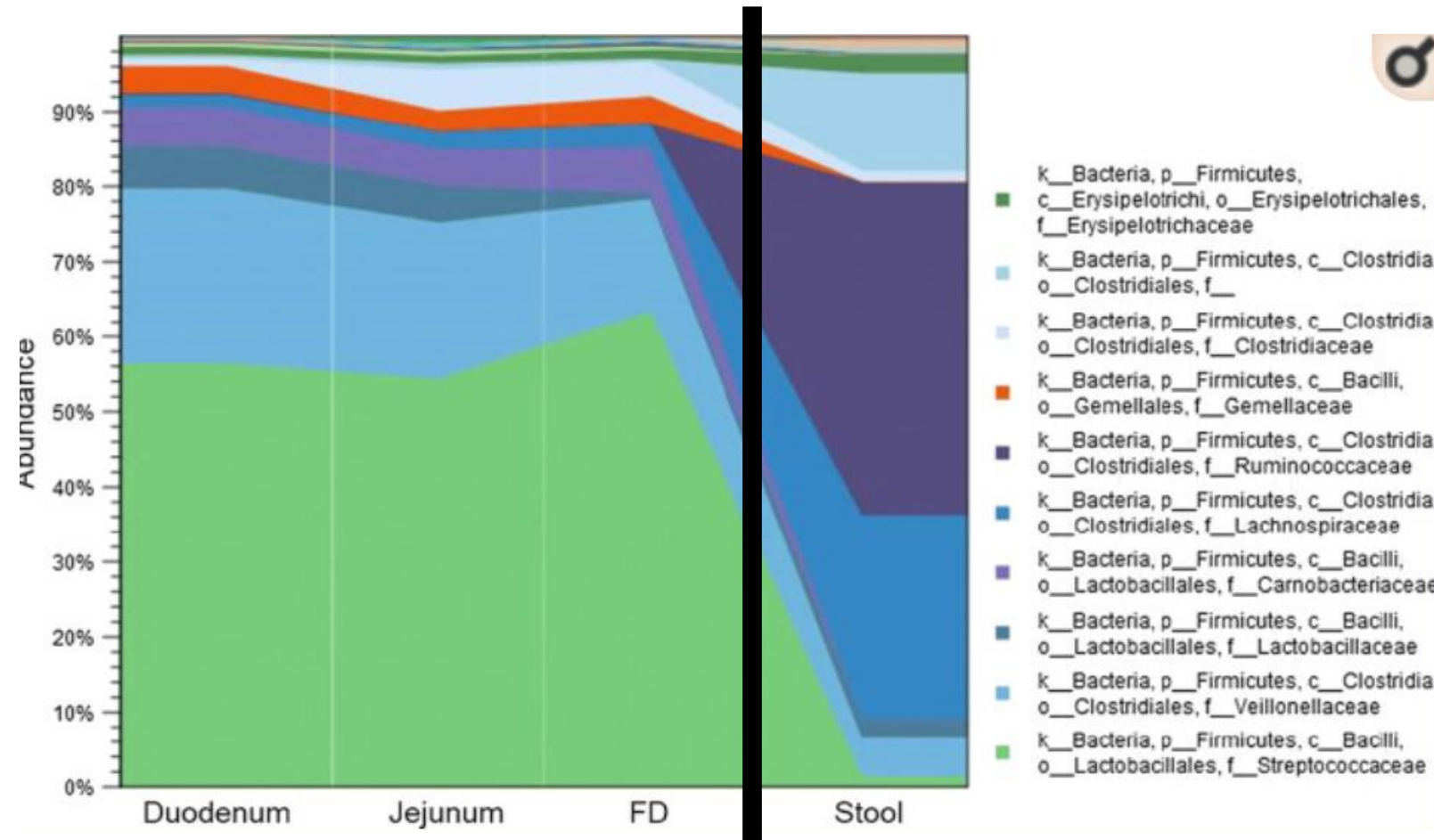
Expensive, difficult, not widely available  
Risk of contamination with oral bacteria  
Does not reach ileum  
CH<sub>4</sub> and H<sub>2</sub>S may be colonic  
Cannot culture anaerobes

## Breath testing

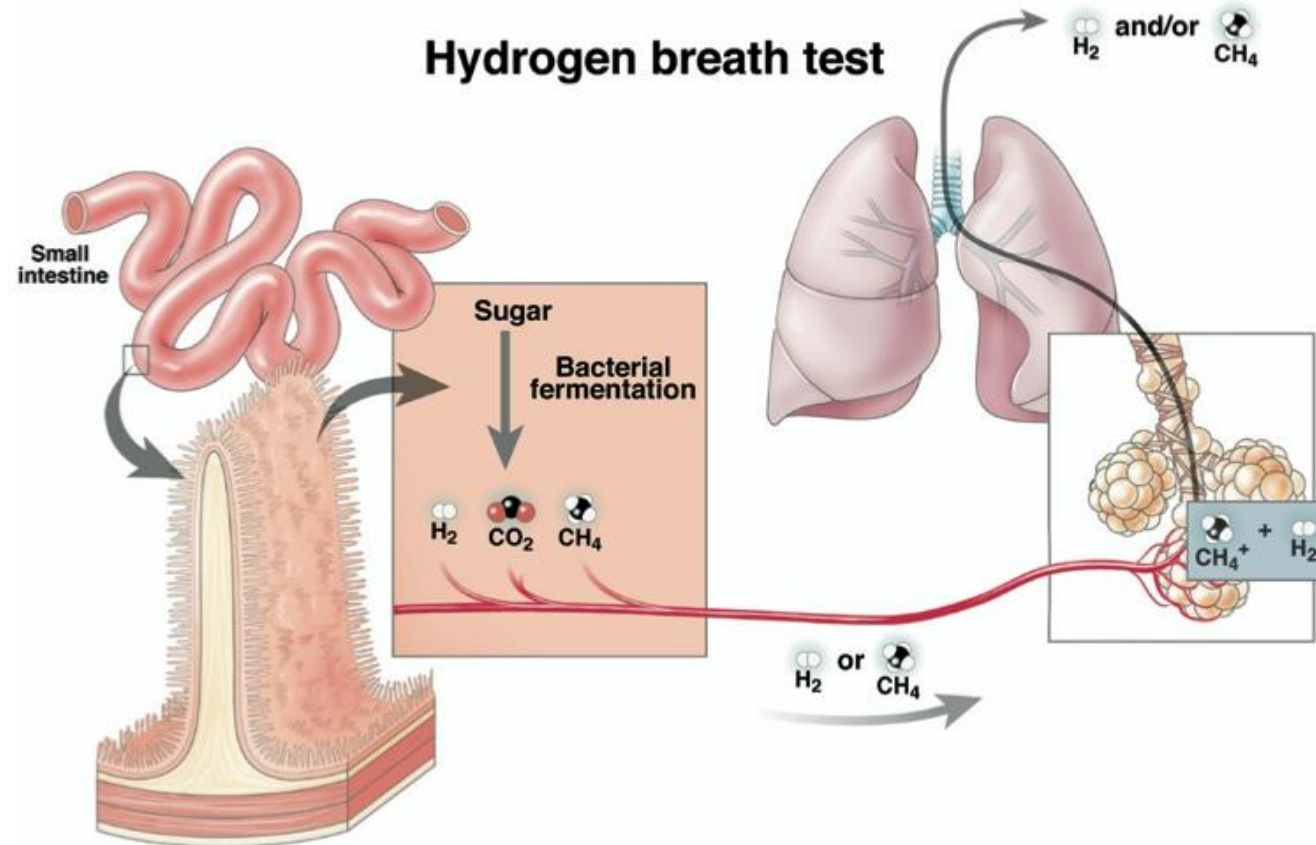
Cheap, easy, widely available  
Reduced sensitivity and specificity  
Whole gut (with lactulose)  
CH<sub>4</sub> and H<sub>2</sub>S detection  
Correlate with stool abundance

**SIBO is defined as  $\geq 10^3$  cfu/mL**  
(Rezaie. Am J G. 2017)

# Stool does not reflect small bowel microbiome



# Diagnosis of SIBO, IMO & ISO



# Diagnosis of SIBO, IMO & ISO

## Glucose

sensitivity 20% to 93%

specificity 30% to 86%

**Higher sensitivity = those with SIBO**

**True positive rate**

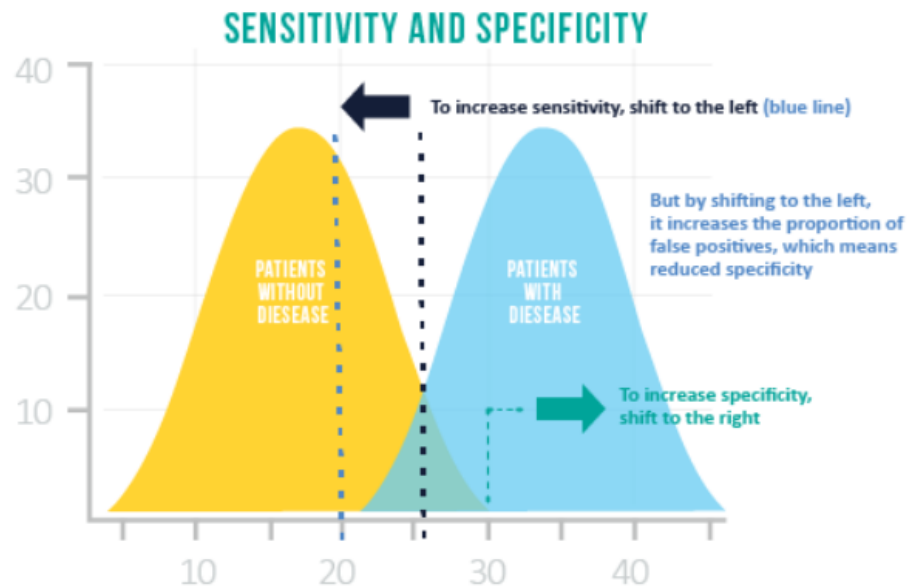
## Lactulose

sensitivity 31% to 68%

specificity 44% to 100%

**Higher specificity = those without SIBO**

**True negative rate**



# Breath testing consensus

|           | AGIP  | NAC  | EAGEN/<br>ESNM/<br>ESPGHAN  |
|-----------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| SIBO      | H <sub>2</sub> ≥20 ppm within 90 min                                                   | H <sub>2</sub> ≥20 ppm within 90 min                                                    | Not specified<br>(use clinical judgement)                                                                      |
| IMO       | ≥10 ppm at any interval                                                                | ≥10 ppm at any interval                                                                 | Not specified                                                                                                  |
| ISO       | Not mentioned                                                                          | Not mentioned                                                                           | Not mentioned                                                                                                  |
| Substrate | 10g lactulose or<br>75g glucose                                                        | 10g lactulose or<br>75g glucose                                                         | 10-20g lactulose or<br>50g glucose                                                                             |

## Guidelines

# British Society of Gastroenterology guidelines on the management of irritable bowel syndrome FREE

- There is no role for testing for exocrine pancreatic insufficiency, or for hydrogen breath testing to rule out small intestinal bacterial overgrowth or carbohydrate intolerance, in patients with typical IBS symptoms (recommendation: strong, quality of evidence: weak).

Article | [Open access](#) | Published: 04 February 2022

## **A systematic review and meta-analysis on the prevalence of non-malignant, organic gastrointestinal disorders misdiagnosed as irritable bowel syndrome**

prevalence of these conditions in secondary healthcare setting. Estimated pooled rates were calculated and statistical heterogeneity between studies was evaluated using Q and  $I^2$  statistics. Seven studies (n = 597) estimated the pooled prevalence for BAD as 41% (95% CI 29–54). 17 studies (n = 5068) estimated that of MC as 3% (95% CI 2–4%). Two studies (n = 478) suggested a rate of 4.6% (range: 1.8–6.1%) for PEI. Using breath testing, 26 studies (n = 6700) and 13 studies (n = 3415) estimated the prevalence of lactose and fructose malabsorption as 54% (95% CI 44–64%) and 43% (95% CI 23–62%); 36 studies (n = 4630) and 22 studies (n = 2149) estimated that of SIBO as 49% (95% CI 40–57%) with lactulose and 19% (95% CI 13–27%) with glucose. Rates of all conditions were significantly higher than in healthy controls. A

# SIBO and IMO prevalence in Rome IV IBS C and D patients

Table 1: Demographics and breath test results at baseline for all IBS participants.

| All IBS (N=121) |           |           |              |           |         |
|-----------------|-----------|-----------|--------------|-----------|---------|
| Age, years      | 35.6±11.0 |           |              |           |         |
| Female          | 88 (72.7) |           |              |           |         |
|                 | 95% CI    |           |              |           |         |
| SIBO            | 79 (65.3) | 56.1–73.7 |              |           |         |
| IMO             | 43 (35.5) | 27.0–44.8 |              |           |         |
| IBS-C (N=61)    |           |           | IBS-D (N=60) |           |         |
| Age, years      | 36.8±10.8 |           | 34.4±11.2    |           |         |
| Female          | 49 (80.3) |           | 39 (65.0)    |           |         |
|                 | 95% CI    |           | 95% CI       |           | p value |
| SIBO            | 35 (57.4) | 44.1–70.0 | 44 (73.3)    | 60.3–83.9 | 0.065   |
| IMO             | 32 (52.5) | 39.3–65.4 | 11 (18.3)    | 9.5–30.4  | <0.001  |

Data are mean ± standard deviation and frequencies (percentages). IBS, irritable bowel syndrome; CI, confidence interval; SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth.

Table 2: Test-retest agreement of breath test results for the placebo group 6-weeks apart.

| All IBS (N=42) | Agreement<br>n (%) | κ    | 95% CI      | p value |
|----------------|--------------------|------|-------------|---------|
| SIBO           | 33 (78.6)          | 0.54 | 0.25 - 0.79 | <0.001  |
| IMO            | 40 (95.2)          | 0.88 | 0.69 - 1.00 | <0.001  |
| IBS-C (N=21)   |                    |      |             |         |
| SIBO           | 17 (80.9)          | 0.60 | 0.19 - 0.90 | 0.006   |
| IMO            | 21 (100)           | 1.00 | 1.00 - 1.00 | <0.001  |
| IBS-D (N=21)   |                    |      |             |         |
| SIBO           | 16 (76.2)          | 0.48 | 0.06 - 0.81 | 0.026   |
| IMO            | 19 (90.5)          | 0.69 | 0.00 - 1.00 | 0.002   |

IBS, irritable bowel syndrome; CI, confidence interval; SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth.

# No test is perfect but...

**$\geq 20$  ppm within 90 minute cut off with lactulose**

Predicts IBS symptoms

(Haworth. Am J G. 2025)

Predicts IBS response to treatment  
& is more cost effective

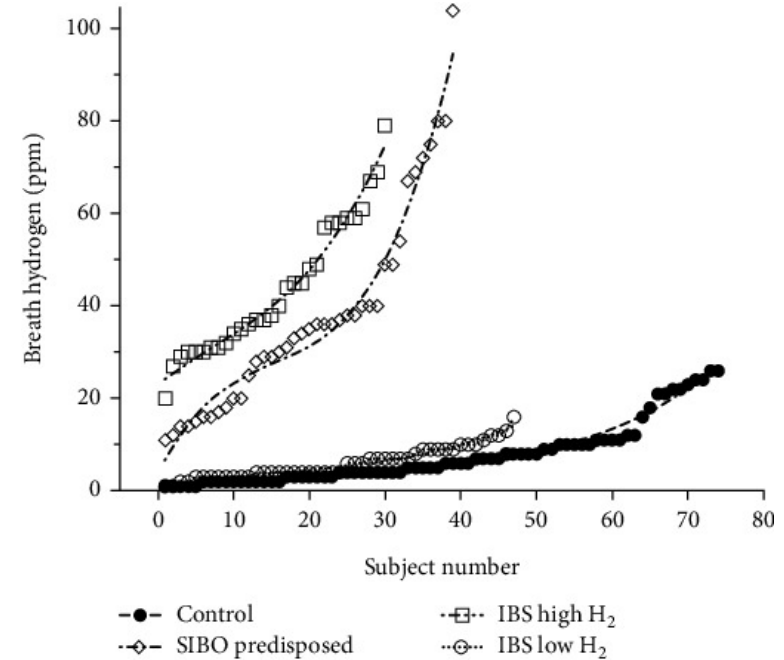
(Rezaie. Am J G. 2019; Chan. CGH. 2023)

Differentiates IBS with sensitivity of 77% and specificity of 88%

(Dahlgreen. Gastro Res Pract. 2025)

Breath correlates with small intestinal abundance

(Villaneuva-Millan. Gastro. 2026)



# Breath test preparation

No antibiotics for 4 weeks ago

Stop prokinetics and laxatives for one week

Stop anti-diarrhoea medications for two days

Stop probiotic supplements for one week

Low fermentation diet for 12 hours

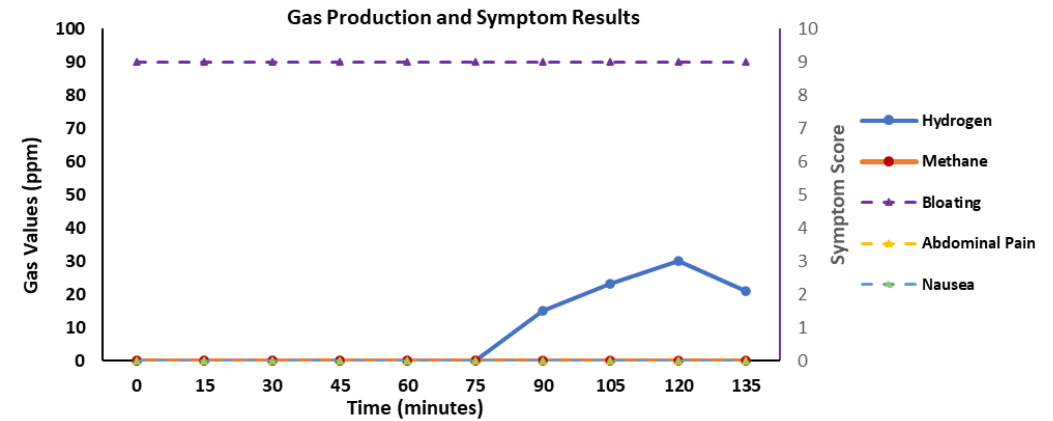
Overnight fast for 12 hours

# Breath test interpretation

## SIBO Negative

$H_2 < 20$  ppm within 90 minutes from baseline

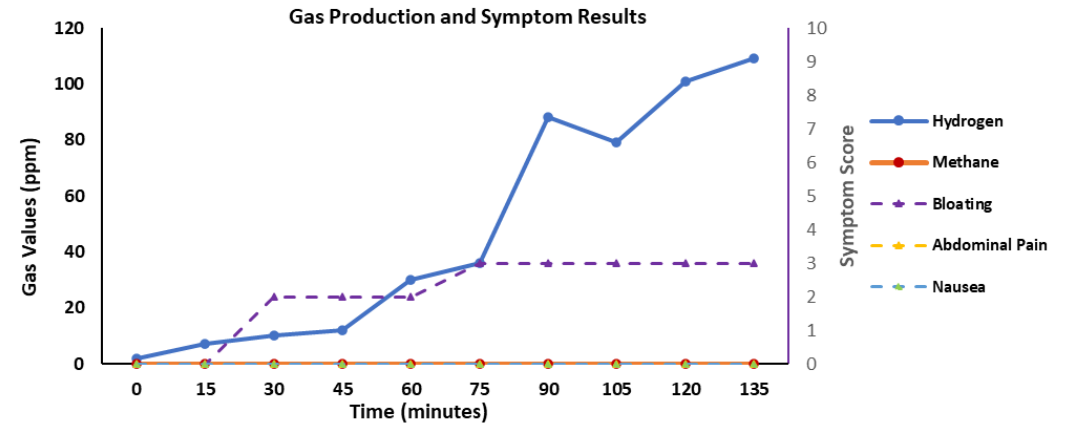
\*Important to measure symptoms



## SIBO Positive

$H_2 \geq 20$  ppm within 90 minutes from baseline

\*Double peak (lactulose only)



# Excessive intestinal fermentation

$H_2 \geq 80$  ppm in second half of test (after 60 minutes) shows strong correlation to symptoms of IBS-D

Table 1: Breath hydrogen peak (ppm) on lactulose breath test and association with symptoms of irritable bowel syndrome.

| Predominant bowel habit | H <sub>2</sub> ppm | Abdominal pain |             |                 | Bloating |        |             | Both            |             |                 |
|-------------------------|--------------------|----------------|-------------|-----------------|----------|--------|-------------|-----------------|-------------|-----------------|
|                         |                    | Any            | Weekly      | Daily           | Any      | Weekly | Daily       | Any             | Weekly      | Daily           |
| Diarrhoea               | 50                 | <b>.001</b>    | .936        | .183            | .862     | .561   | .639        | .850            | .685        | .118            |
|                         | 60                 | <b>.012</b>    | .153        | <b>.013</b>     | .530     | .788   | .176        | .304            | .350        | <b>.010</b>     |
|                         | 70                 | .065           | .104        | <b>.013</b>     | .430     | .542   | .108        | .335            | .289        | <b>.025</b>     |
|                         | 80                 | .149           | <b>.005</b> | <b>&lt;.001</b> | .091     | .125   | <b>.024</b> | <b>.030</b>     | <b>.010</b> | <b>&lt;.001</b> |
|                         | 90                 | .099           | <b>.016</b> | <b>.007</b>     | .063     | .094   | <b>.019</b> | <b>.026</b>     | <b>.024</b> | <b>.006</b>     |
| Mixed                   | 50                 | .332           | .670        | .495            | .261     | .444   | .964        | .244            | .640        | .976            |
|                         | 60                 | .980           | .887        | .457            | .737     | .609   | .459        | .881            | .986        | .843            |
|                         | 70                 | .907           | .789        | .511            | .610     | .299   | .324        | .950            | .552        | .951            |
|                         | 80                 | .977           | .892        | .838            | .663     | .466   | .687        | .995            | .654        | .921            |
|                         | 90                 | .185           | .217        | .168            | .483     | .617   | .720        | .271            | .465        | .295            |
| Constipation            | 50                 | <b>.001</b>    | <b>.004</b> | .075            | .261     | .444   | .964        | <b>&lt;.001</b> | <b>.009</b> | <b>.035</b>     |
|                         | 60                 | <b>.012</b>    | <b>.039</b> | .157            | .737     | .609   | .459        | <b>.010</b>     | <b>.048</b> | .056            |
|                         | 70                 | .065           | .087        | .324            | .610     | .299   | .324        | .081            | .133        | .089            |
|                         | 80                 | .149           | .252        | .206            | .663     | .466   | .687        | .172            | .289        | .052            |
|                         | 90                 | .099           | .192        | .196            | .381     | .686   | .527        | .114            | .190        | .081            |

Significant associations ( $p < 0.05$ ) indicated in bold.

Darker green = greater positive association. Darker red = greater negative association.

# Breath test interpretation

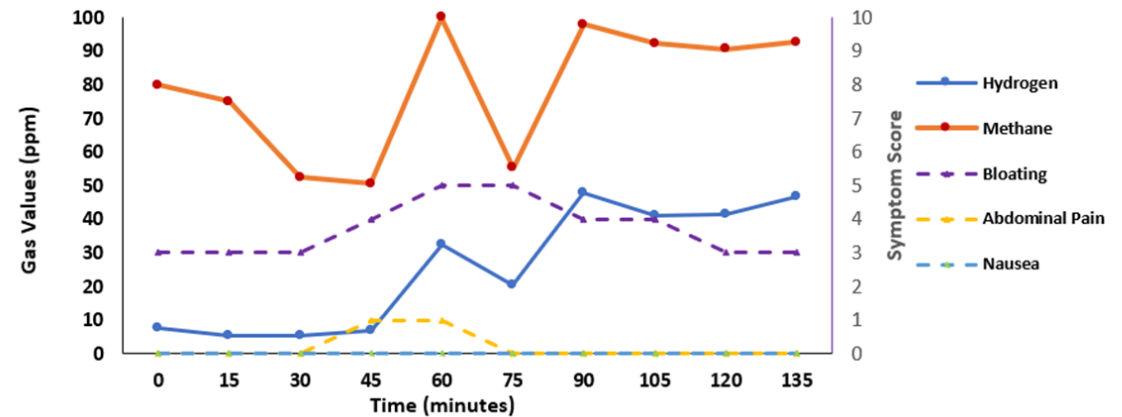
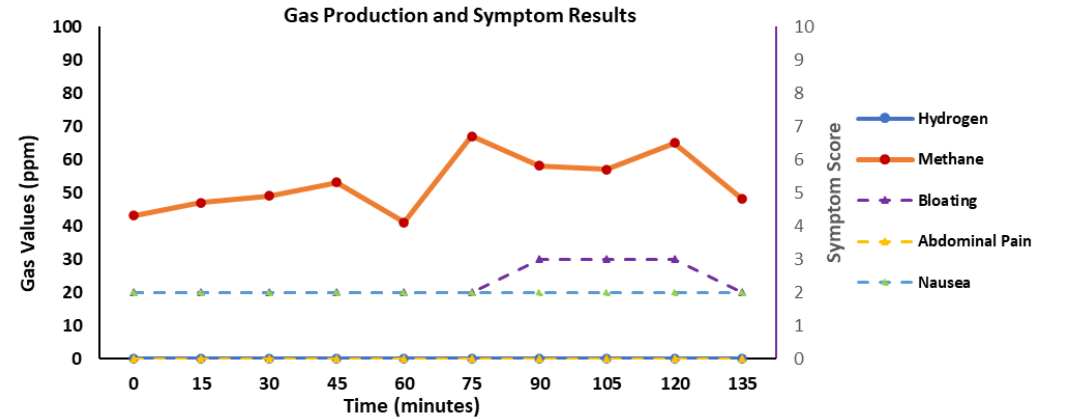
## IMO Positive

$\text{CH}_4 \geq 10$  ppm at any interval

Typically elevated at baseline

Fasted or spot methane sample

Possible to have both SIBO & IMO



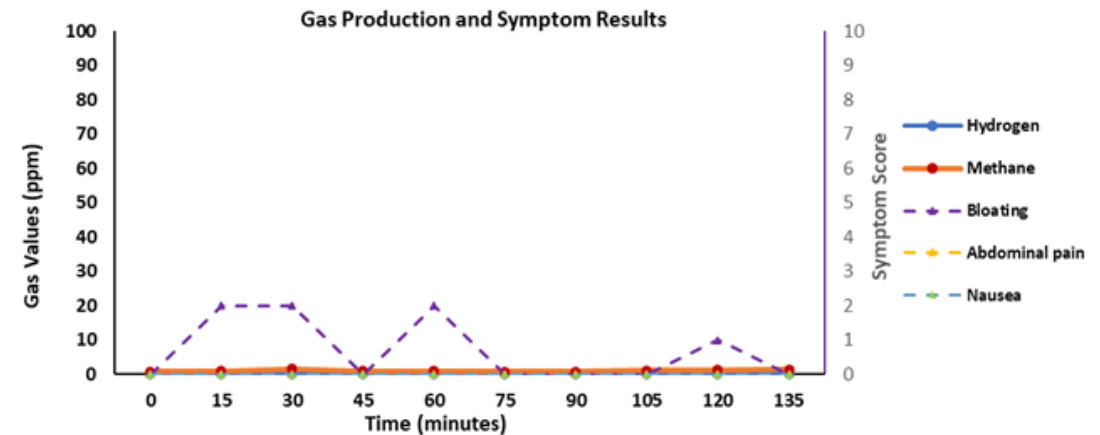
# “Flatline” Breath Test

No H<sub>2</sub> or no rise H<sub>2</sub>

1. Delayed oro-cecal transit time
2. Hydrogen sulphide

\*Lactulose only (glucose fully absorbed)

56% respond to antibiotics  
(Rezaie. Am J Gastro. 2020)



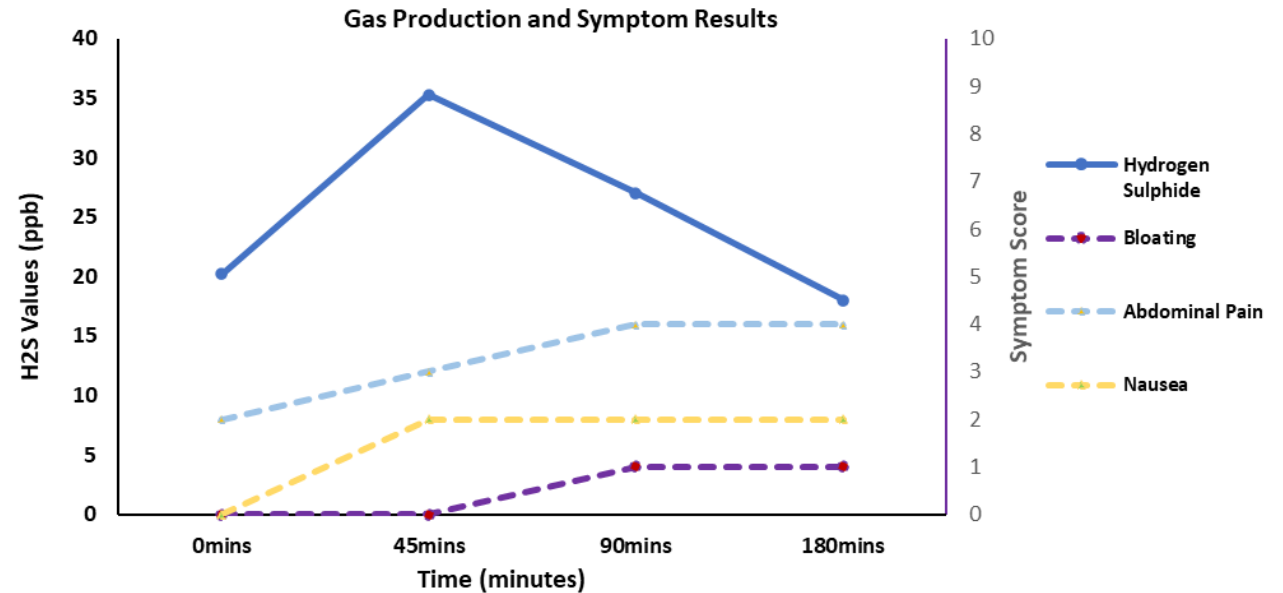
# Hydrogen sulphide

$\text{H}_2\text{S} \geq 25$  ppb at any interval

Note ppb **not** ppm

Much more sensitive

What is endogenous vs exogenous?



# Treating SIBO

Rifaximin is a non-adsorbable antibiotic

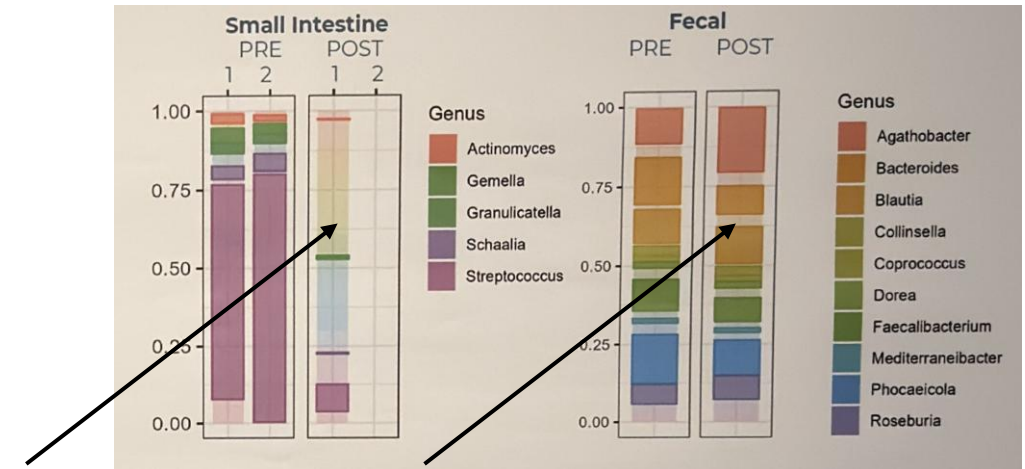
Only works in the small intestine

Activated by bile acids

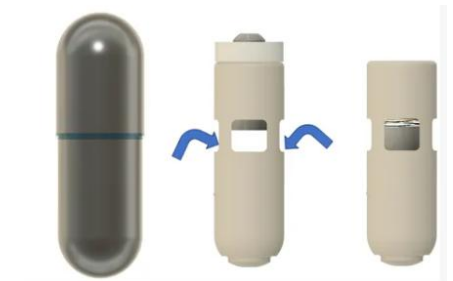
Safe to take repeat courses without AMR risk

Only licenced for travellers diarrhoea and hepatic encephalopathy in UK

Not licenced for SIBO or IBS so private prescription may be expensive



Rifaximin caused profound changes in small intestine but not stool microbiome (Bundalovic-Torma. GmFH. 2026)



# Treating SIBO

Rifaximin 550mg t.i.d 14 days

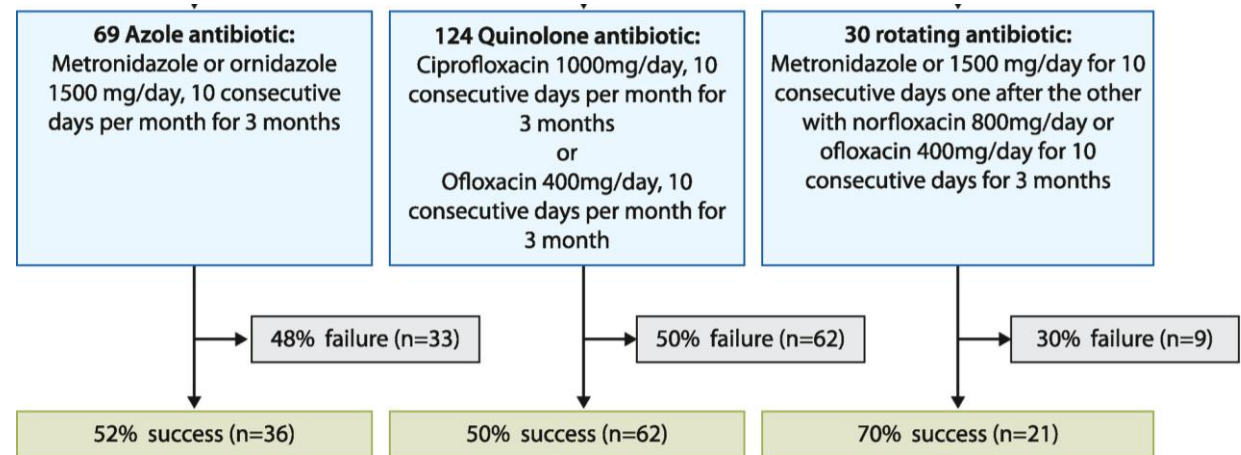
59% efficacy pooled meta-analysis (Lu. Frontiers. 2026)

Rifaximin 200mg t.i.d. 14 days + 600mg NAC

80% efficacy (Pimentel. Gastro. 2025)

Rotating antibiotics vs single antibiotics

70% vs 50% efficacy (Richard. UEG J. 2021)

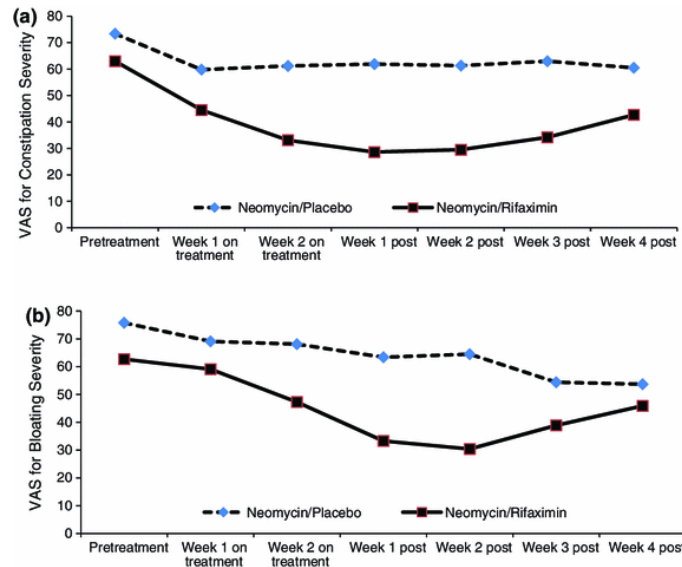


Adapted from Richard. UEG J. 2021

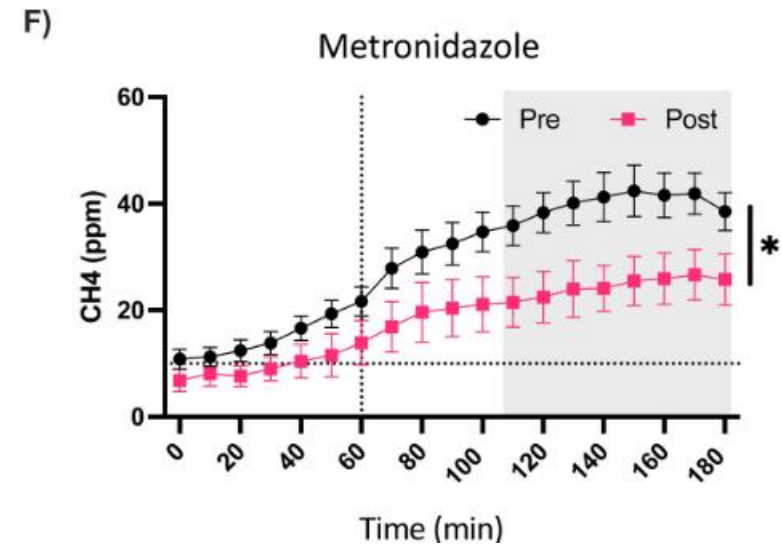
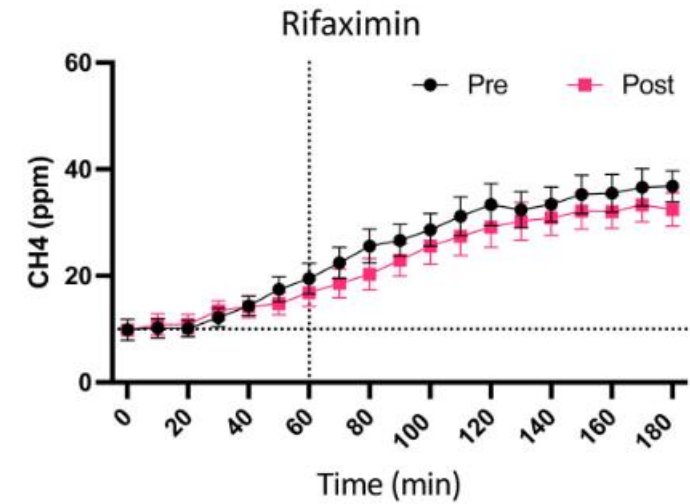
# Treating IMO

Rifaximin + neomycin/metronidazole 500mg t.i.d

Eradication 87% vs 33% vs 27% (Low. J Clin Gastro. 2010)



Adapted from Pimentel et al. Dig Dis Sci. 2014



Muhlenbrock. Rev Gastro Mexico. 2025

# Treating IMO

Rifaximin has more favourable safety profile to other antibiotics

Rifaximin targets bacterial beta-subunit RNA polymerase (*rpoB* gene)

Archaea more likely overgrow in colon

Methane is not toxic

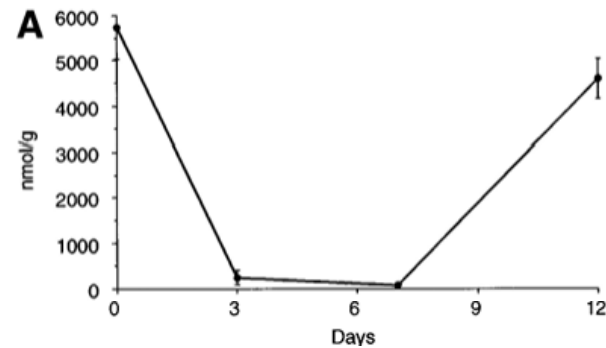
May be more pragmatic to manage constipation

- Low fermentable fibre: kiwis, psyllium, PHGG
- Osmotic laxatives: magnesium oxide, PEG
- Stimulant laxatives: aloe, bisacodyl

# Treating H<sub>2</sub>S

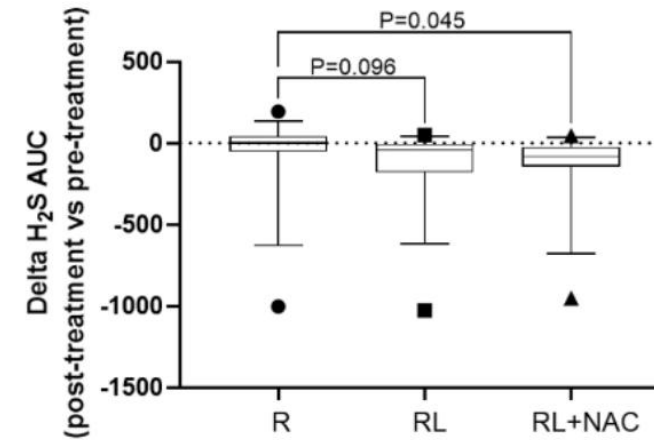
Rifaximin 200mg t.i.d 14 days + NAC 600 mg t.i.d 14 days

Bismuth subsalicylate (524mg q.i.d. 3-7 days)



Adapted from Suarez. Gastro. 1998

H<sub>2</sub>S differences post- vs pre-treatment



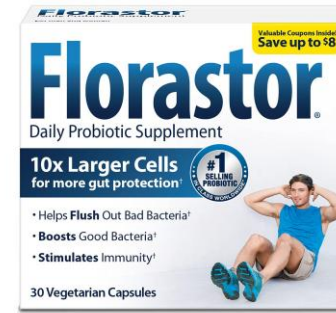
Adapted from Pimentel. Gastro. 2025

# Probiotics

SIBO

***S. boulardii CNCM i745***

(Fernandez. Dig Dis. 2023; Efremova. J Clin Med. 2024; Maev. Ter Arkh. 2025)



IMO

***L. reuteri DSM 17938***

(Ojetti Eur Rev Med Pharm Sci. 2017)



SIBO/IMO

**Multistrain liquid probiotic** improves small intestinal transit time

(FGC to be published)



# Other treatments

## SIBO

FC Cidal + Dysbiocide  
Candibactin AR + BR  
Intestinal adsorbent  
Olive leaf



Otterstad. Gut. 2022

Howell. Gut. 2022

## IMO

Atrantil  
JUVIA



Haworth. Gut. 2022



Brenner. Gastro. 2025



Chedid. Glo Adv Heal Med. 2014



Zafar. Front Nutr. 2025

# Diet

Diet CAN manage symptoms

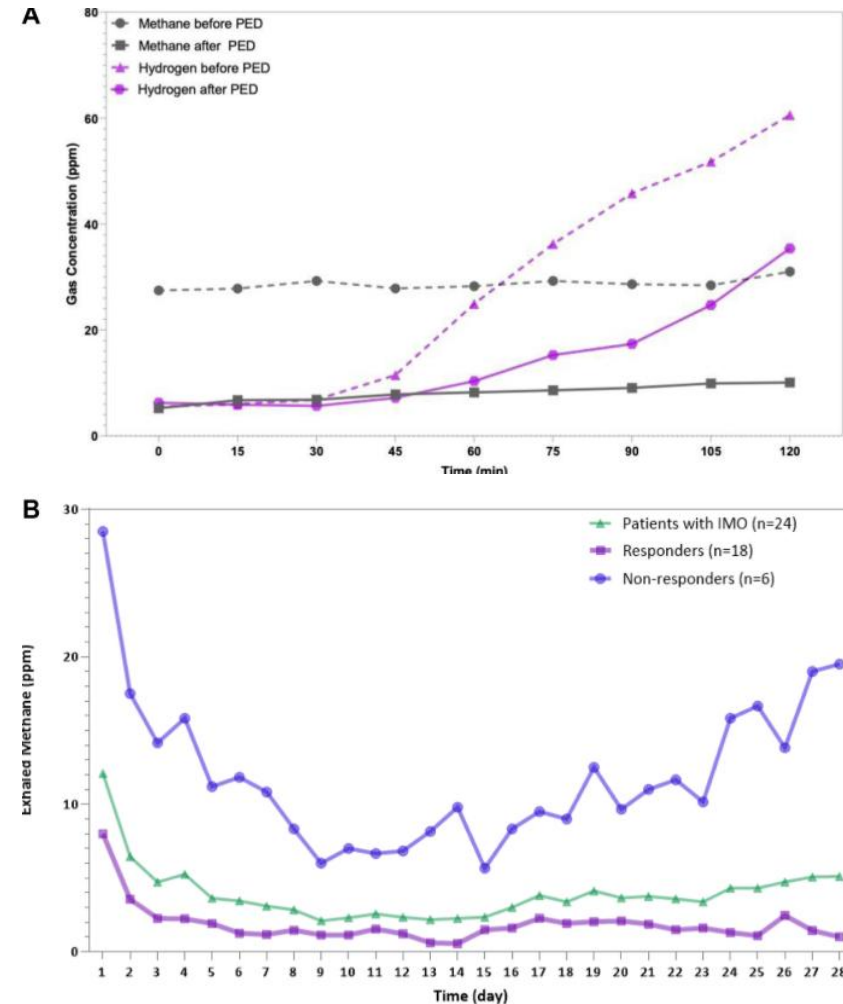
There is a lack of dietary studies in SIBO

Space meals 4-5 hours apart to activate MMC

Healthy fats to stimulate bile flow on rifaximin

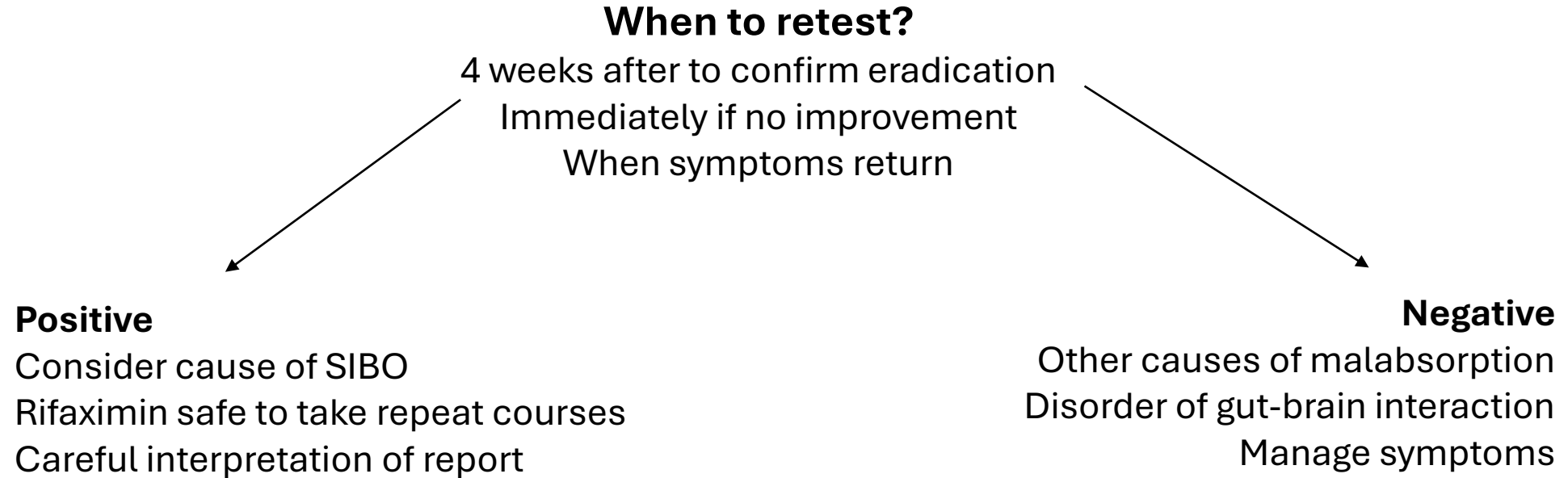
Low FODMAP is the most effective diet for IBS  
(Cuffee. Lancet. 2025)

Elemental diet is a last resort  
(Rezaiei. CGH. 2025)



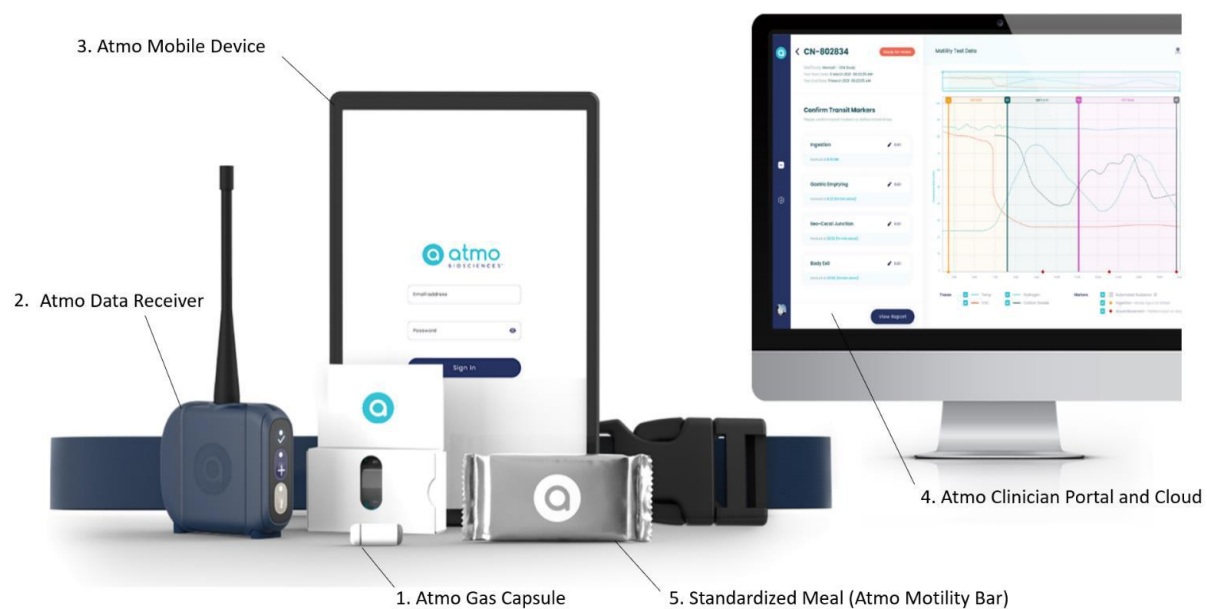
Adapted from Rezaie. CGH. 2015

# Follow up



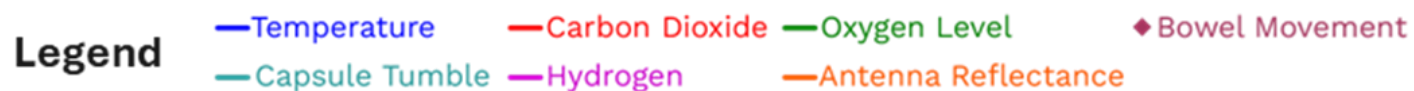
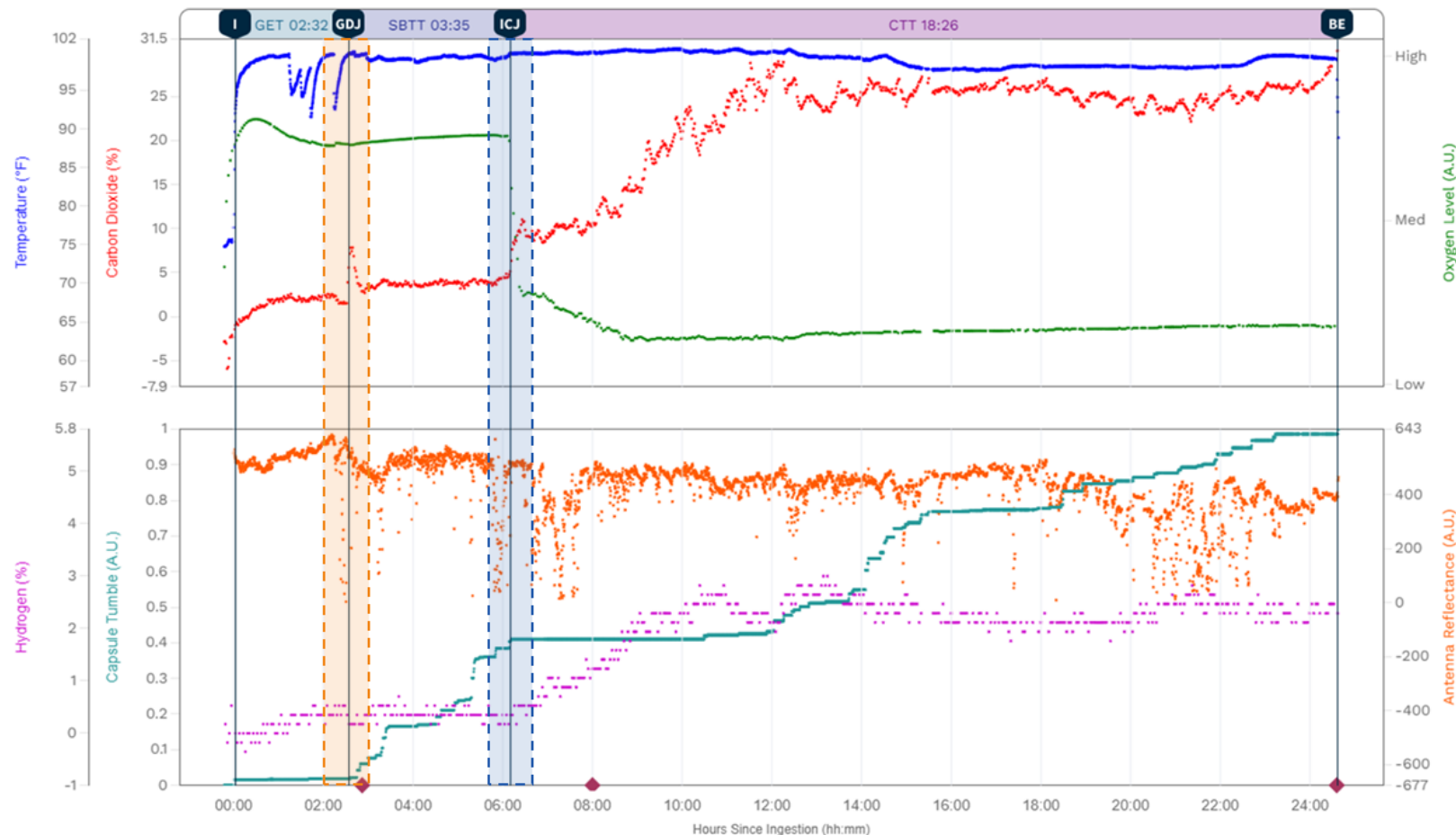
# The Near Future.....

# ATMO Gas sensing capsule – whole gut motility

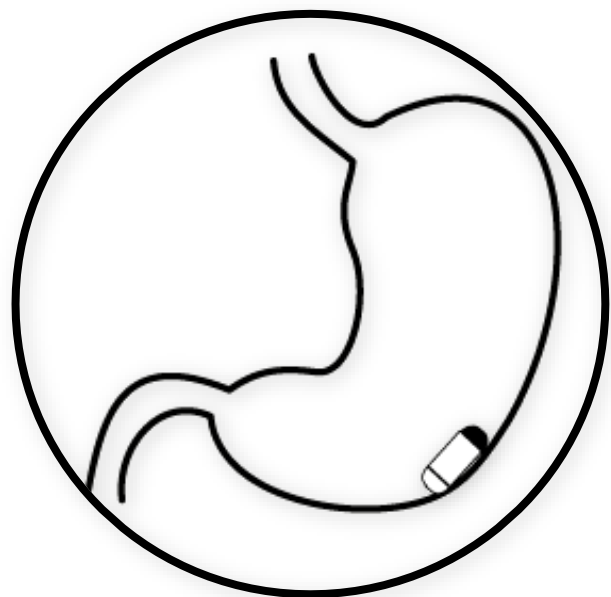


# The Atmo Gas Capsule

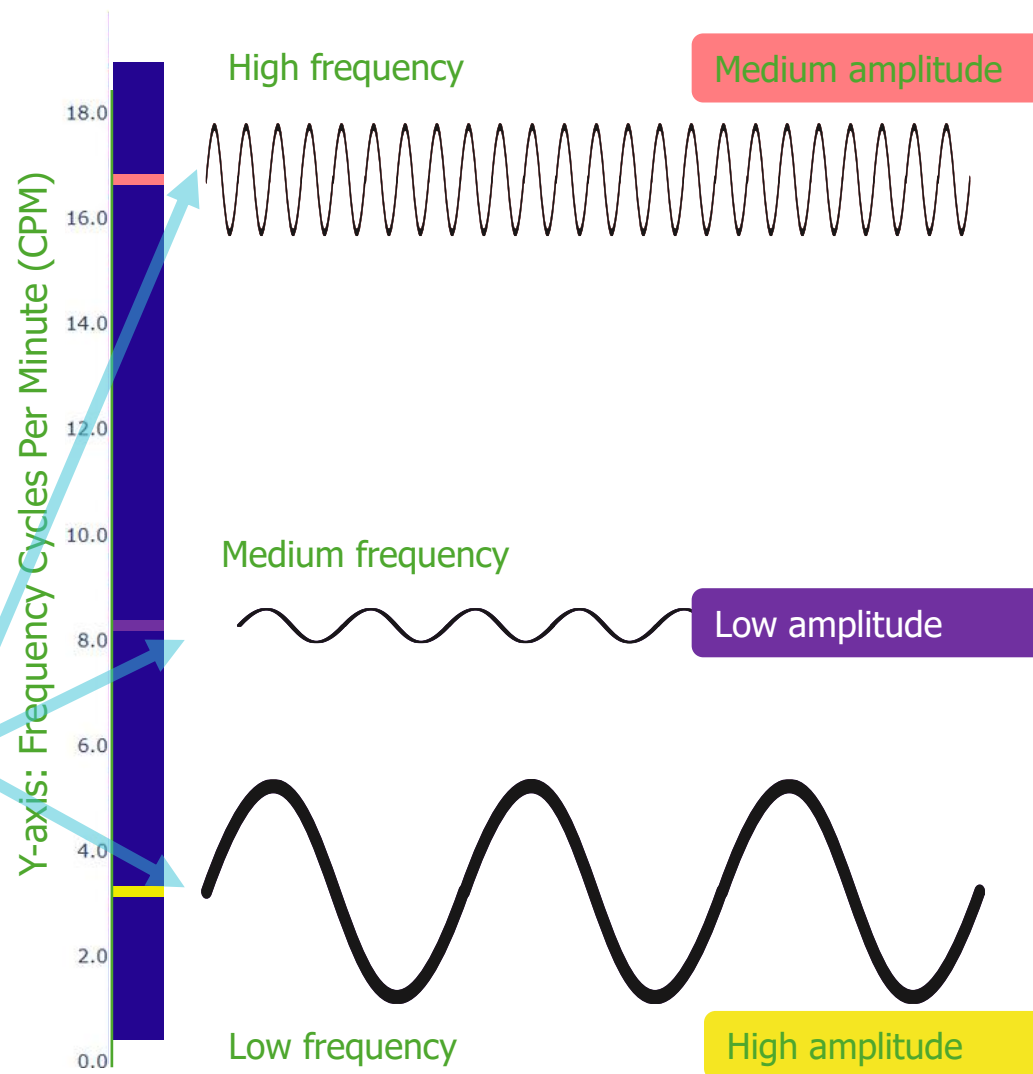
The Atmo Gas Capsule is an FDA-cleared wireless motility capsule that senses gases and other modalities to detect GI landmarks and allow measurement of transit metrics.



# The Atmo Gas Capsule: Looking Forward



Contractions are broken down to multiple frequencies.



The energy (intensity) of the frequency is its amplitude.



Low

High

Amplitude intensity  
visualized by colour scale

The Technology

# The SIMBA™ Capsule

 [Discover How](#)



Single use device to collect **endoscopic quality fluid** samples from the previously inaccessible small intestine.



We've made the small intestine accessible — with a **simple, swallowable device**.



**Timed sampling. Real insights.** Capture multi-omic GI data at timepoints related to real-time changes in the intestinal tract.

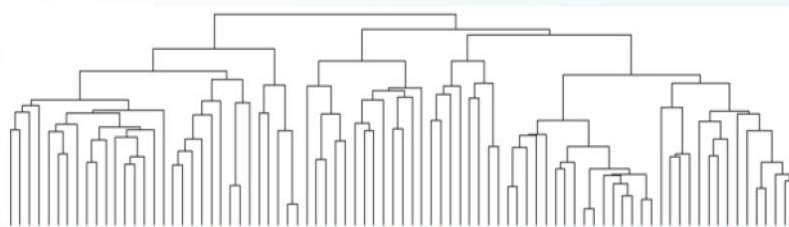
Health Canada class II licensed medical device  
In all other jurisdictions, it is used as an investigational device in authorized studies

# SIMBA Data

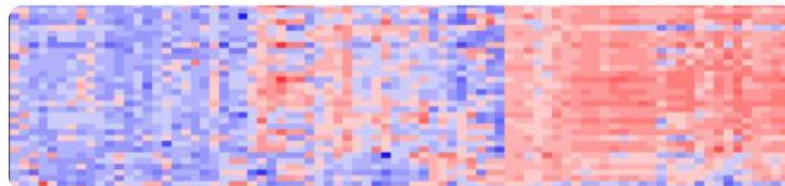
The highest quality multi-omic GI data

N|MBLE

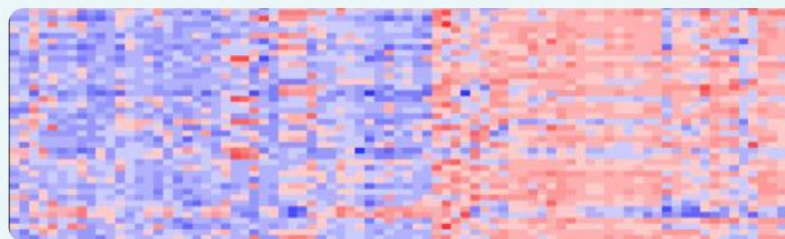
Source



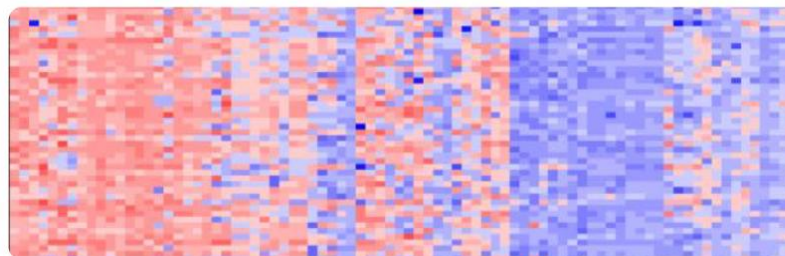
Endoscopy



SIMBA Capsule



Fecal Sample



- Metabolomics
- Metagenomics
- Proteomics
- Transcriptomics
- Lipidomics
- IgA

**SIMBA** Capsule data sets are comparable to Endoscopy and different from Fecal.



# Summary

- Patients with ‘functional’ GI conditions make up >50% of GI referrals
- Huge advances in technology to objectively assess these patients
- Results linked to actionable treatments and positive outcomes
- Holistic approach encompassing Brain-gut and Microbiome
- An MDT approach provides end to end solutions for patients and clinicians guiding evidence based, appropriately staged treatments and improving outcomes.
- Have confidence that if patients need to be ‘escalated’ we have the expertise to move these patients along the clinical pathway safely and effectively.