

THE MAGIC OF OUR “MICROBIOMES”

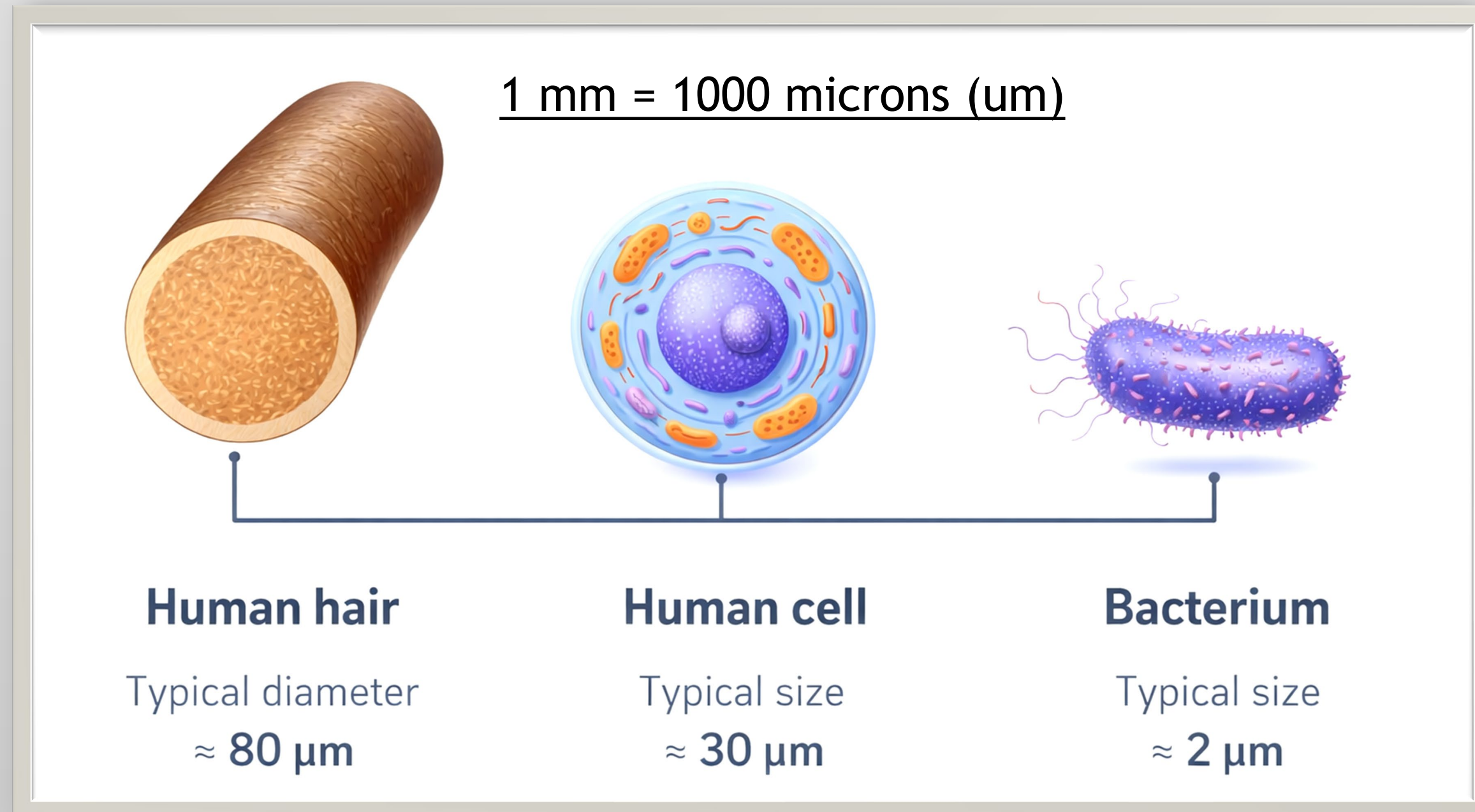
OUR HIDDEN BACTERIAL GARDENS

(Grow where the sun don't shine)



SIZE DOESN'T MATTER!

SMALL THINGS PERFORM OUTSTANDING TASKS IN THE HUMAN BODY!!



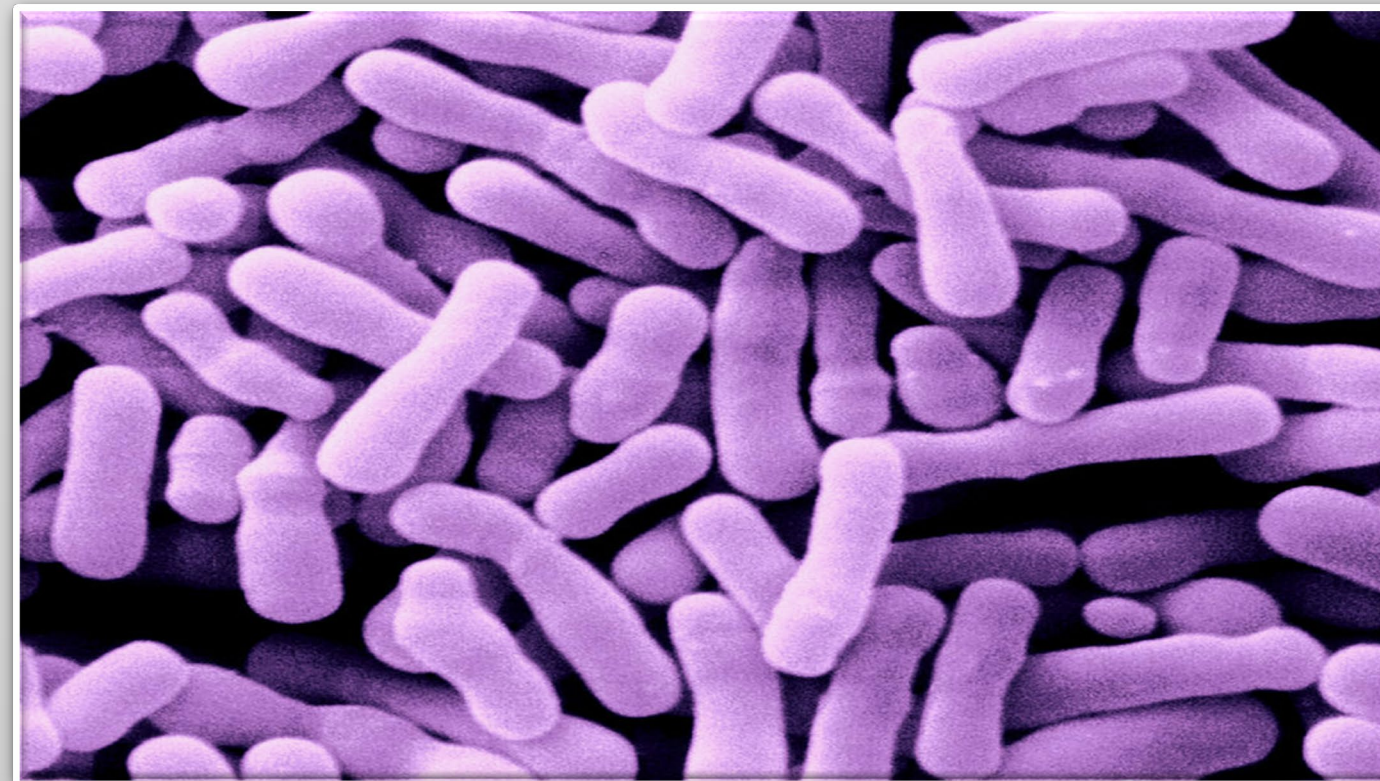
**30 trillion in
human body**

**40 trillion in
human body**

WHAT ARE BACTERIA? (1)

FOUND EVERYWHERE:

- **Single-celled microbes**
- Have been found at an **altitude of 30-40 km** - three times higher than an airliner
- The **International Space Station** carries many bacterial species (inside and on exterior panels), that came from astronauts and Earth and that can survive for many years in space
- Routinely inhabit the seafloor all the way down to the **deepest ocean trenches** (e.g. ca. 11 km)



Scanning Electron Micrograph of a
Bifidobacterium species

- Digitally colorised
- About 10,000 times magnification

WHAT ARE BACTERIA (2)



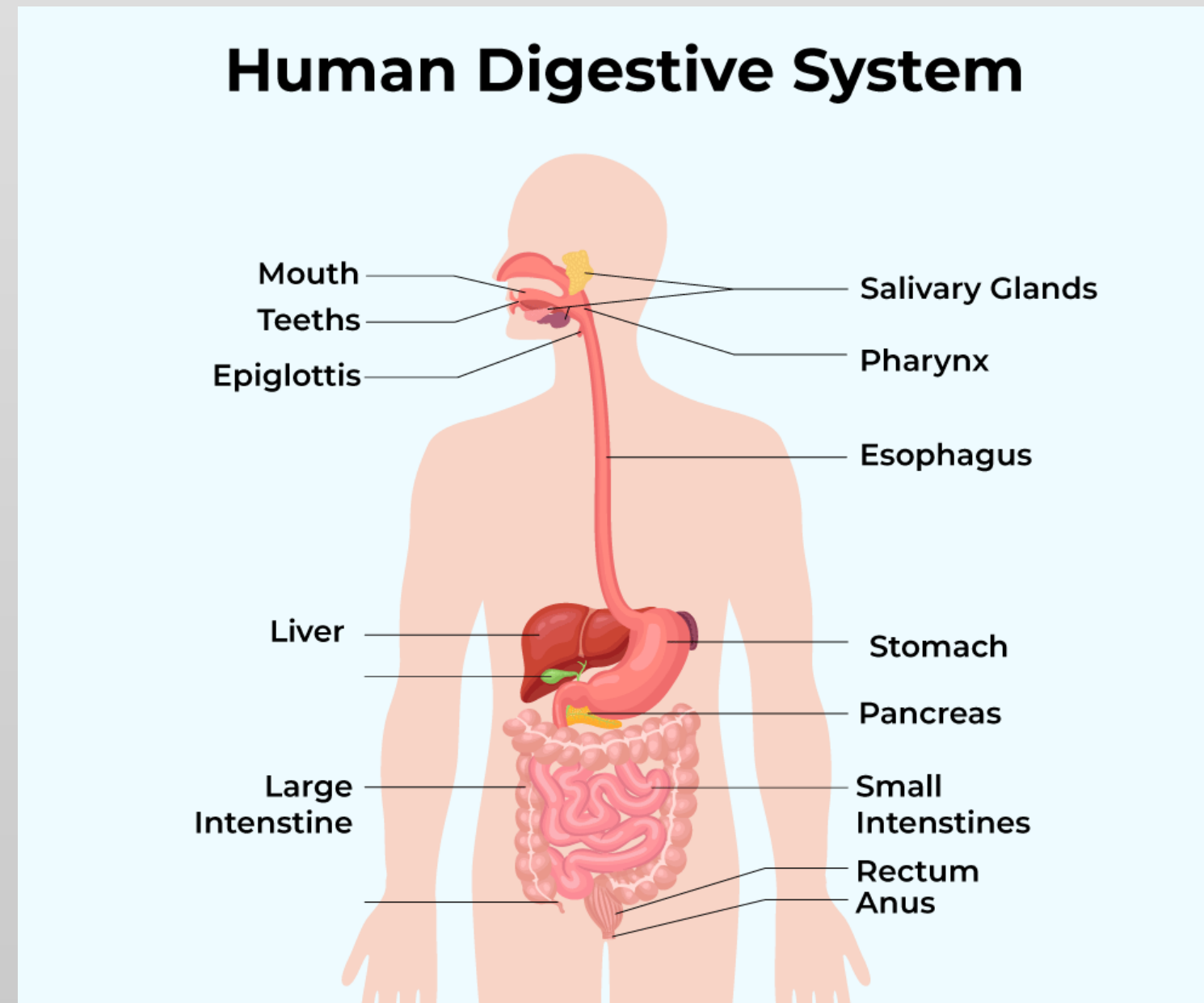
- Also occur in **soil, freshwater, polar ice, hot springs, and on/in all plants and animals - INCLUDING ON/IN HUMANS**
- Probably **been around for 3.5 billion years.** (We - Homo sapiens - first appeared roughly 300,000 years ago)
- **THE VAST MAJORITY ARE HARMLESS OR EVEN BENEFICIAL!**

THE GUT MICROBIOME

THE HUMAN DIGESTIVE SYSTEM

The Digestion Process:

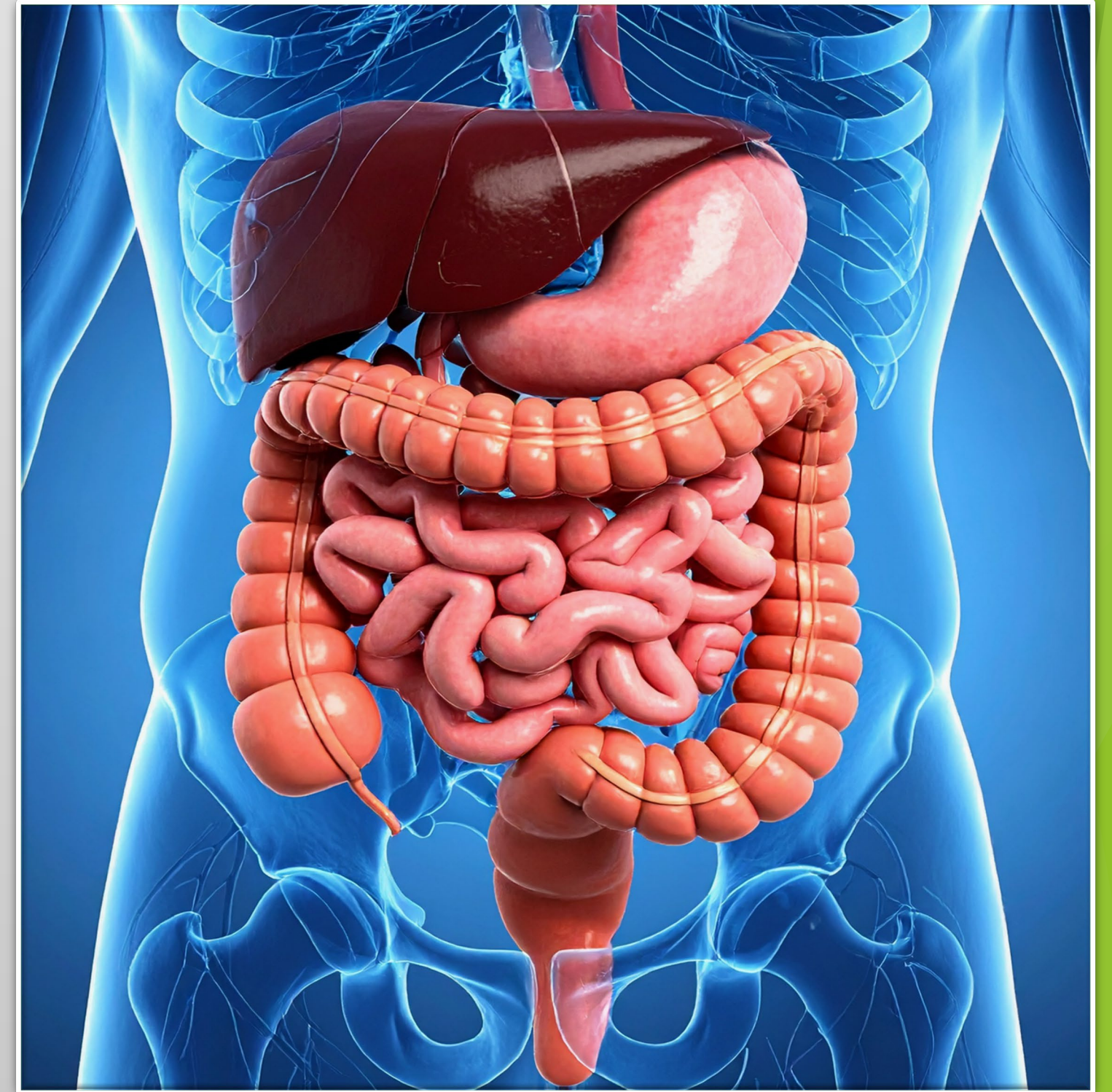
1. **Mouth and stomach:** start digestion and mechanical breakdown.
2. **Small intestine:** does most of the digestion and almost all the absorption.
3. **Large intestine (Colon):** mainly reabsorbs water and forms stools.
HOWEVER ...”



THE GUT (COLON) MICROBIOME

IT HOSTS A POPULATION OF BENEFICIAL BACTERIA

- That **live on the gut lining** (in the lumen and mucus)
- Home to **many trillions of different types of bacteria** (and very small proportion of other microbes - e,g, yeasts & fungi)
- Estimated that all the bacteria on and inside an average adult human weigh around 200 grams
- Composition begins at **birth (vaginal) &/or during breast feeding** - reaches maturity after 2-4 years
- Changes throughout life based upon **diet, lifestyle, environment, health & socio-economic status**



EACH PERSON HAS A UNIQUE MICROBIOME

OTHER MICROBIOMES

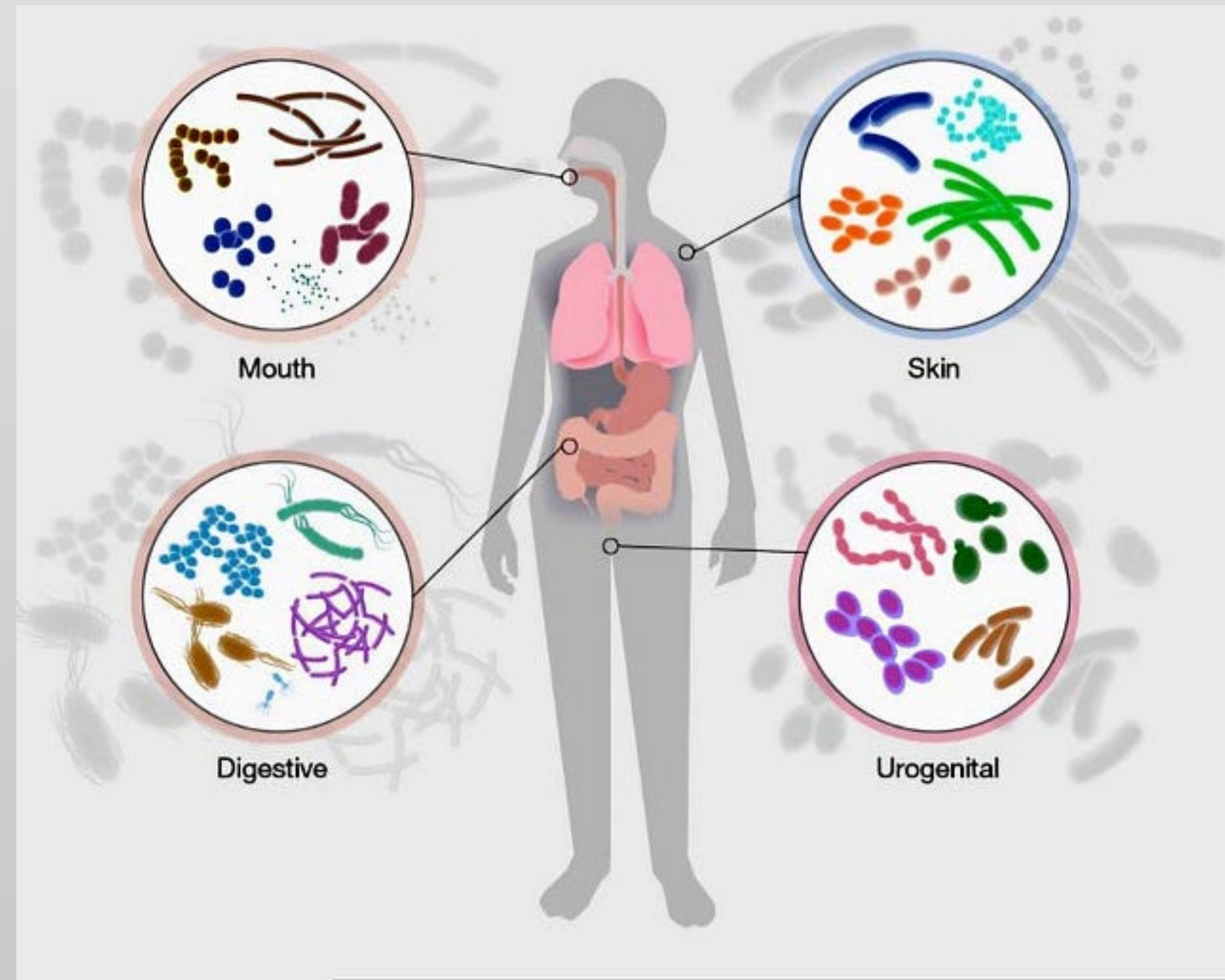
OTHER MICROBIOMES

OTHER POPULATIONS OF BENEFICIAL BACTERIA OUTSIDE & INSIDE THE BODY!

THE MAJOR MICROBIOMES
ARE CONSIDERED TO BE THE:

- Mouth
- Skin
- Urogenital/Vaginal, and
- GUT (COLON)

(The largest,
best-characterised
communities)



PRODUCTION OF SHORT CHAIN FATTY ACIDS (SFCAs) IN THE GUT MICROBIOME

- The microbiome is composed of a multitude of differing **anaerobic fermentation processes, working in unison** -
 - Production of SCFAs begins with breakdown of plant fibres (**which aren't broken down in stomach & small intestines**) by, for example:
 - ❑ ***Prevotella copri*, *Bifidibacterium longum* & *Akkermansia muciniphila*.**
 - Followed by further breakdown of products, by following bacteria, to produce SCFAs: ***Faecalibacterium prausnitzii* & *Roseburia intestinalis***



THE GUT MICROBIOME

IMPORTANCE OF SHORT CHAIN FATTY ACIDS

WHY “SHORT CHAIN FATTY ACIDS”

Short chains:

CH_3COOH (acetic acid)

$\text{CH}_3\text{CH}_2\text{COOH}$ (propionic acid)

$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (butyric acid)

Fatty acids:

Because they're derived from fats; eg butyric acid is derived from Tributyrin (glycerol tributyrate), which is found in butter

SHORT CHAIN FATTY ACIDS (SCFAs) act as **important “messenger” molecules** that let the gut microbiome “talk” to other organs via, for example **the circulatory and nervous systems**.

(Can you spot the SCFA in the diagram??)



CIRCULATION OF SCFAS AND THEIR IMPACT ON KEY ORGANS

CIRCULATION ORDER AND MAIN IMPACTS of SCFAs:

Gut microbiome: **source of SCFAs**

Liver: protect against **fatty liver disease**

Heart: heart burns acetic acid (acetate) as fuel and SCFAs help **keep heart muscle healthy**

Brain: help **reinforce the brain's protective barrier** and calm inflammation, **potentially protecting against brain (neurological) disorders**

Skin: help skin cells **build a stronger protective outer layer**, which keeps allergens and irritants out and **reduces inflammatory skin conditions**

OTHER “MESSENGER” MOLECULES

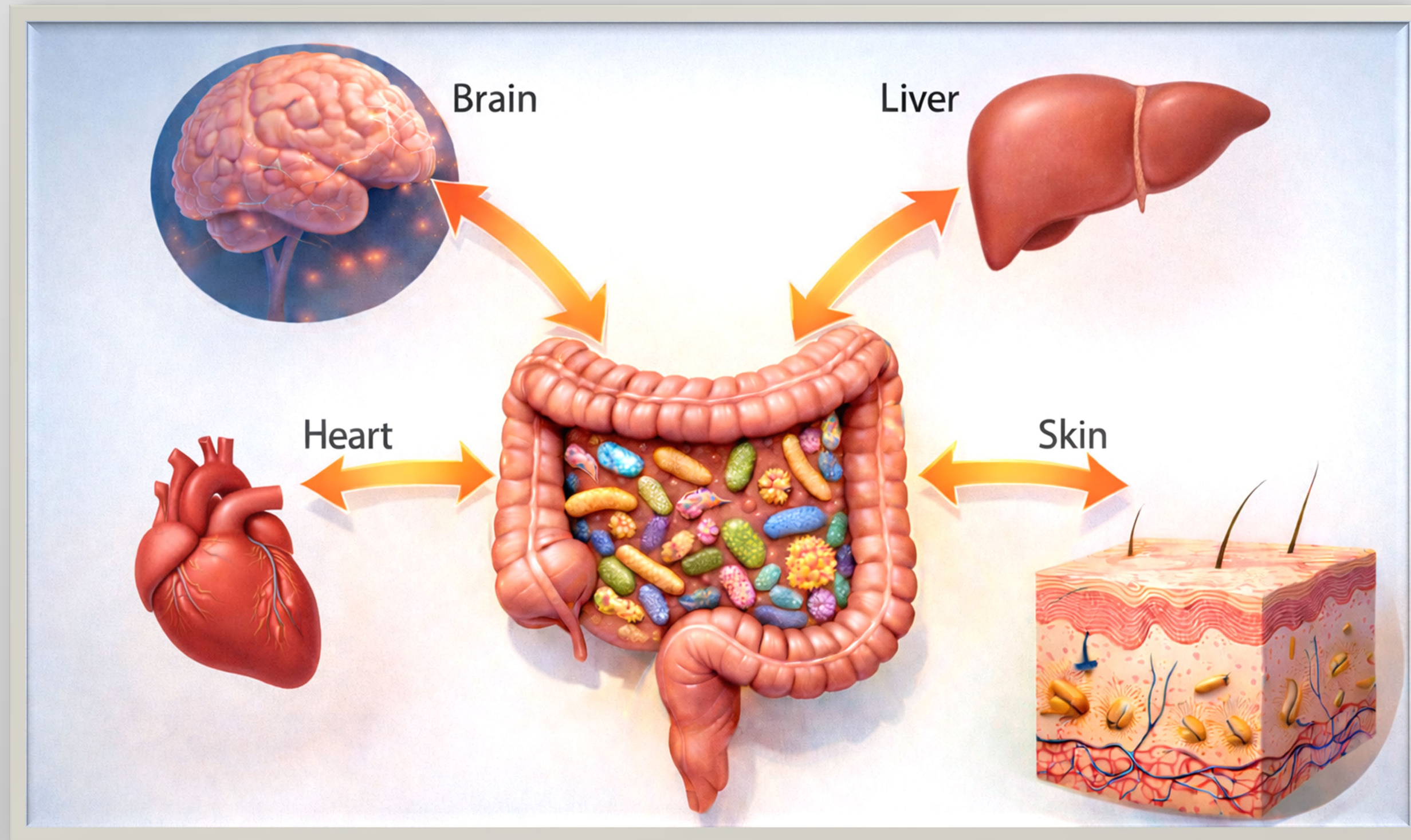
Apart from SCFAs a variety of **other “messenger molecules”** are employed by the gut to ‘talk’ to other organs via the circulatory system, including:

- **Hormones**
- **Neurotransmitters**
- **Bile-acid, and even**
- **Tiny fragments of bacteria themselves**

GUT-ORGAN AXES

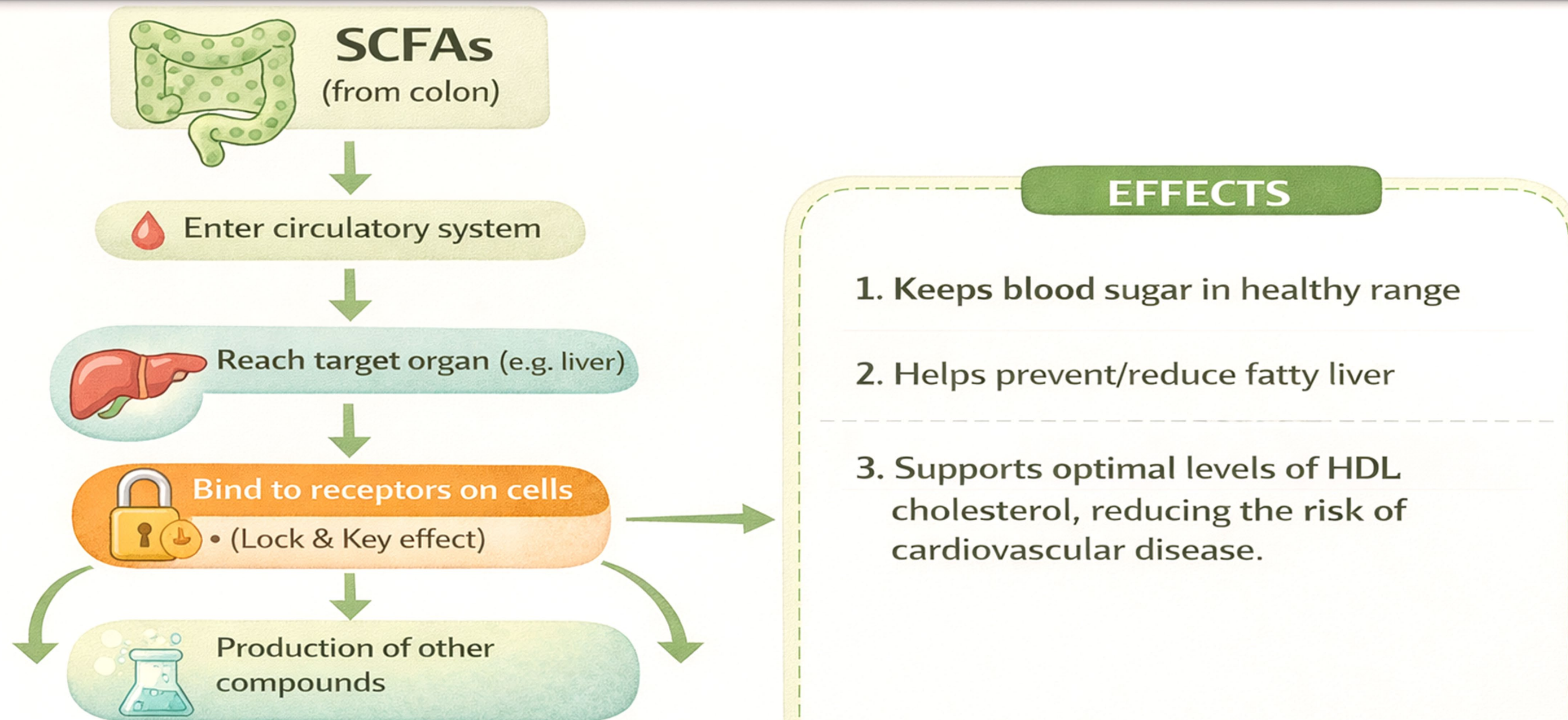
GUT-ORGAN AXES

PRIMARILY THE ABILITY OF GUT, BRAIN, HEART, LIVER & SKIN TO
“TALK” TO EACH OTHER



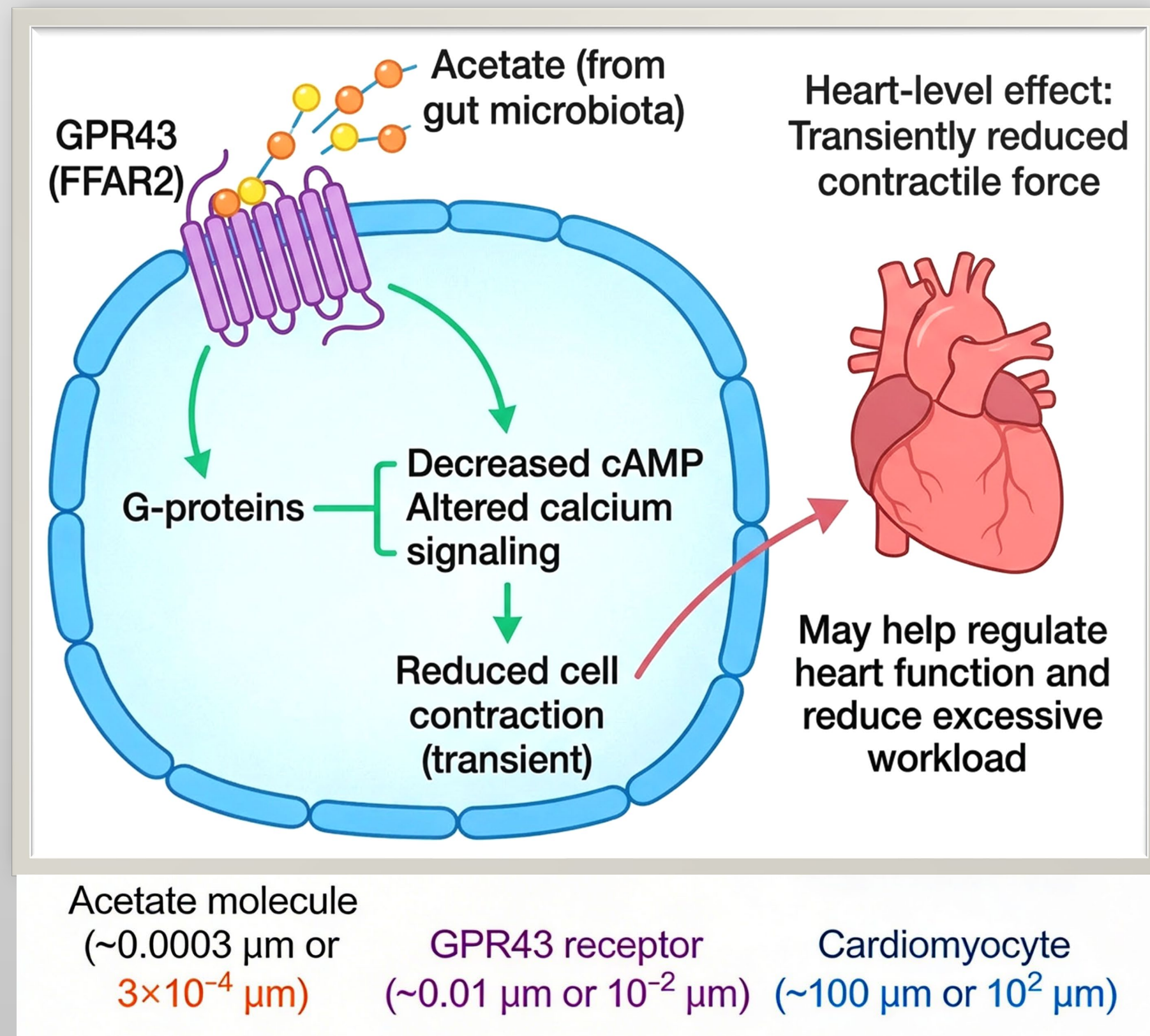
GUT-ORGAN AXES: HOW THEY COMMUNUCATE

ROLE OF SCFAs IN GUT-LIVER AXIS



THE GUT-HEART AXIS

IMPACT OF SCFA MOLECULE ON HEART CELL (AND HEART) VIA CIRCULATORY SYSTEM



SIZE DOESN'T MATTER!

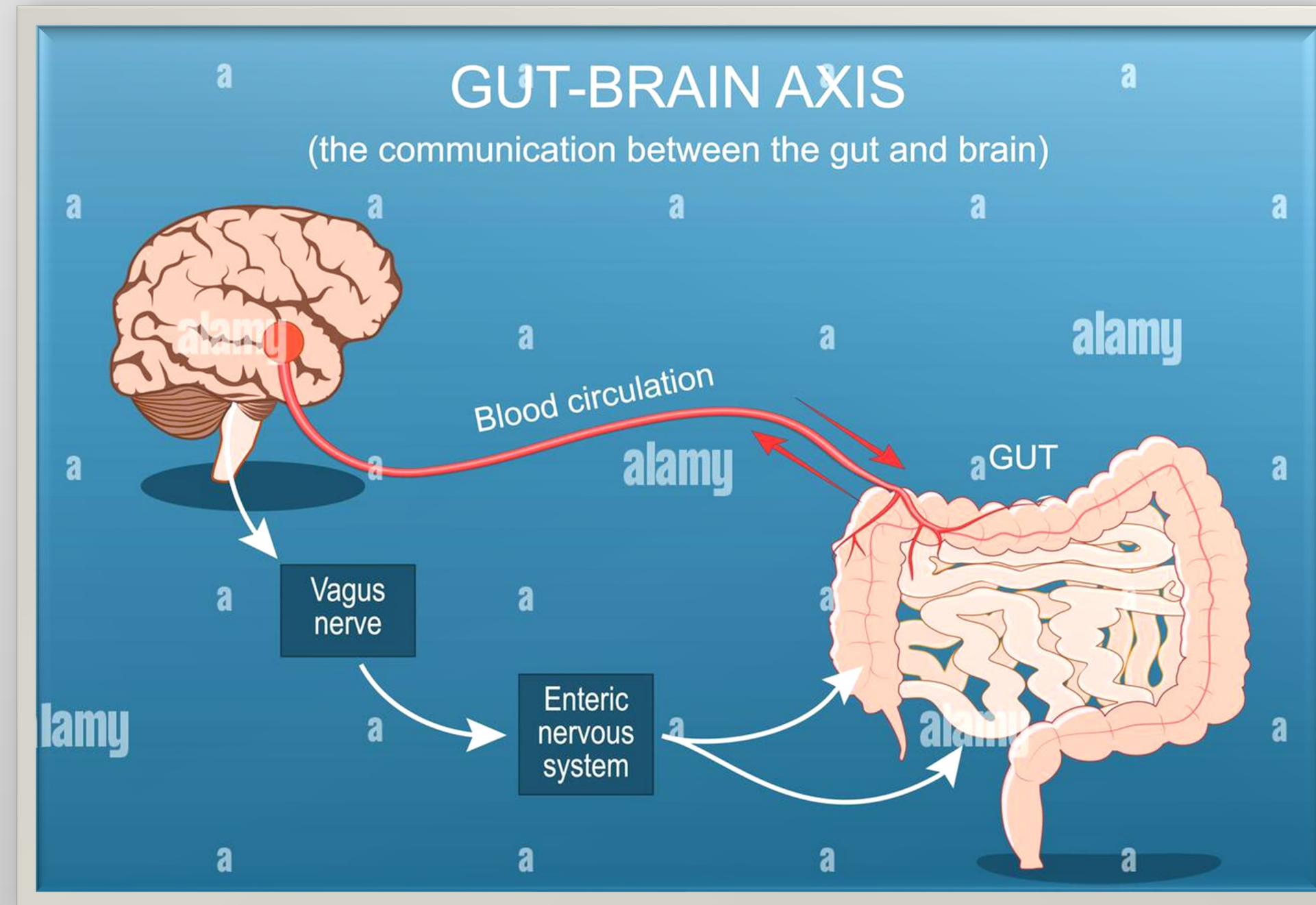
A **small acetic acid molecule** can have a significant impact on the heart - although a **heart cell** is $\sim 300,000\times$ larger than an acetate molecule!

THE GUT-BRAIN AXIS

THE GUT-BRAIN AXIS

Operates VIA :

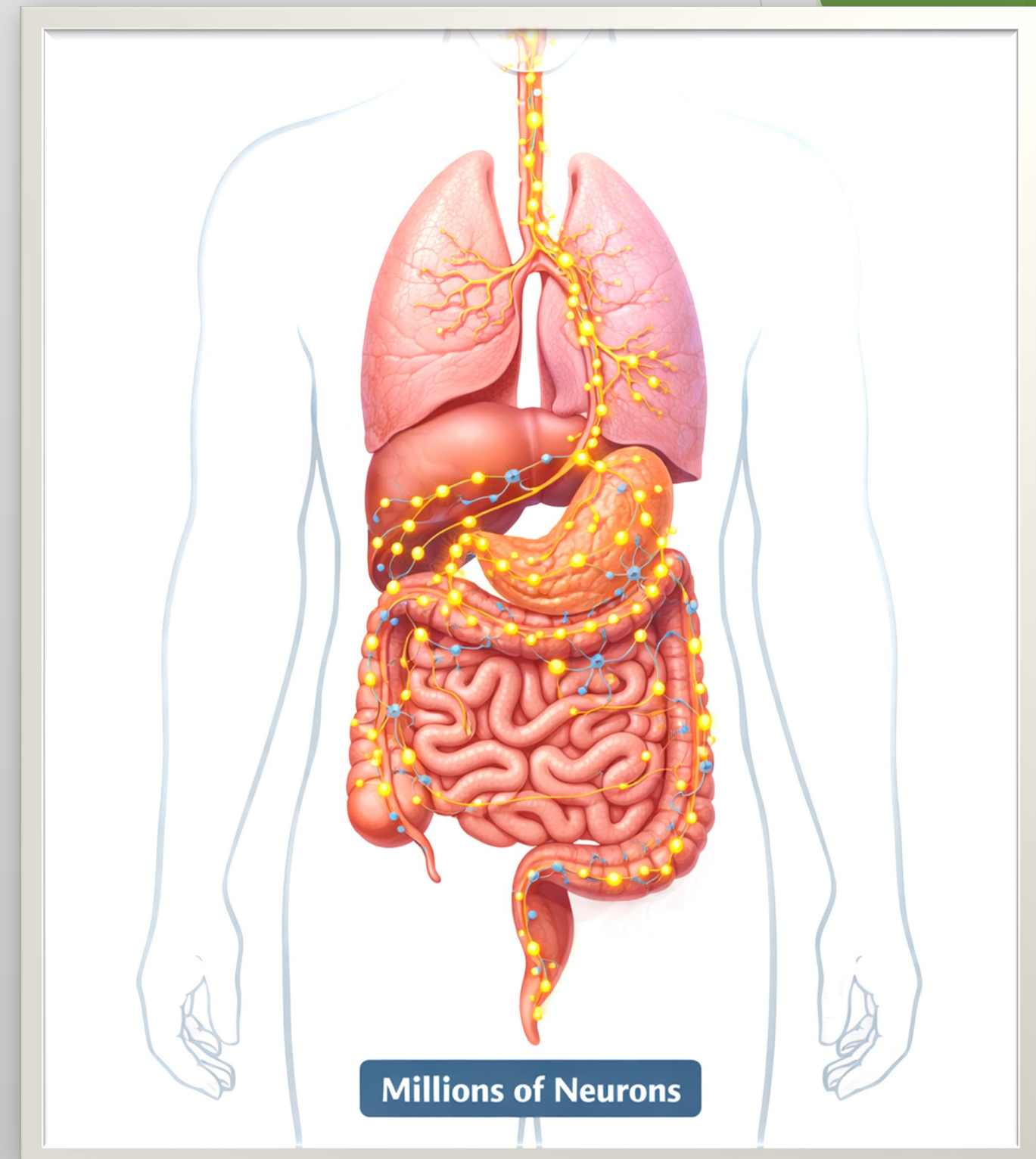
- SCFAs
- BLOOD CIRCULATION
- THE ENTERIC NERVOUS SYSTEM
- THE VAGUS NERVE



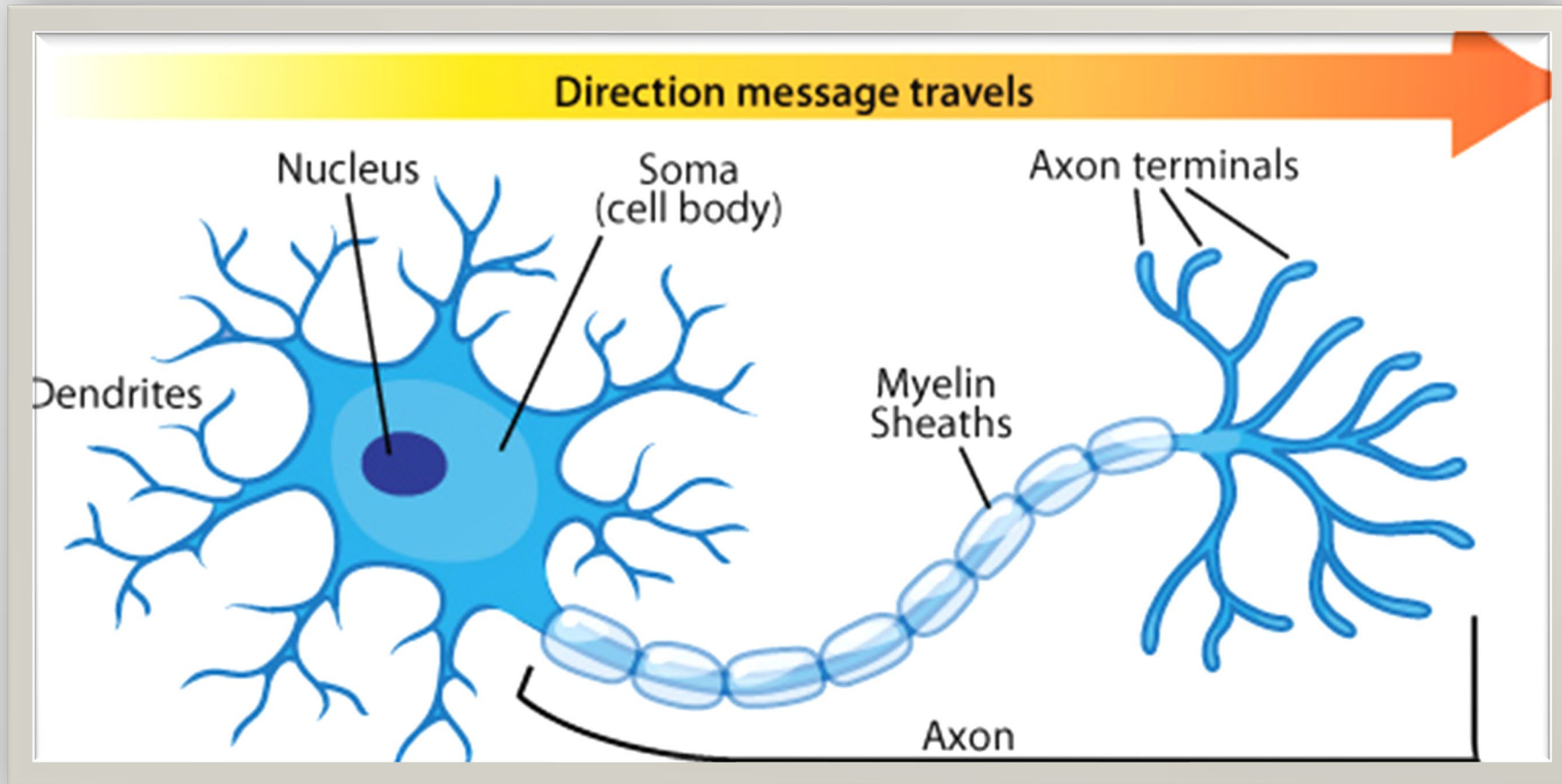
THE ENTERIC NERVOUS SYSTEM

OUR SECOND BRAIN

- Runs the whole length of the digestive tract, from mouth to the anus, working with not for the brain:
 - hundreds of millions of nerve cells (neurons) that sit in the wall of the digestive tract
 - coordinates rhythmic waves of contraction and relaxation (peristalsis) that push food down the digestive tract
 - adjusts enzyme and acid release depending on what is in the gut
 - helps sense harmful substances or infections in the gut
 - triggers defence responses such as speeding transit (diarrhoea), or initiates vomiting in extreme cases

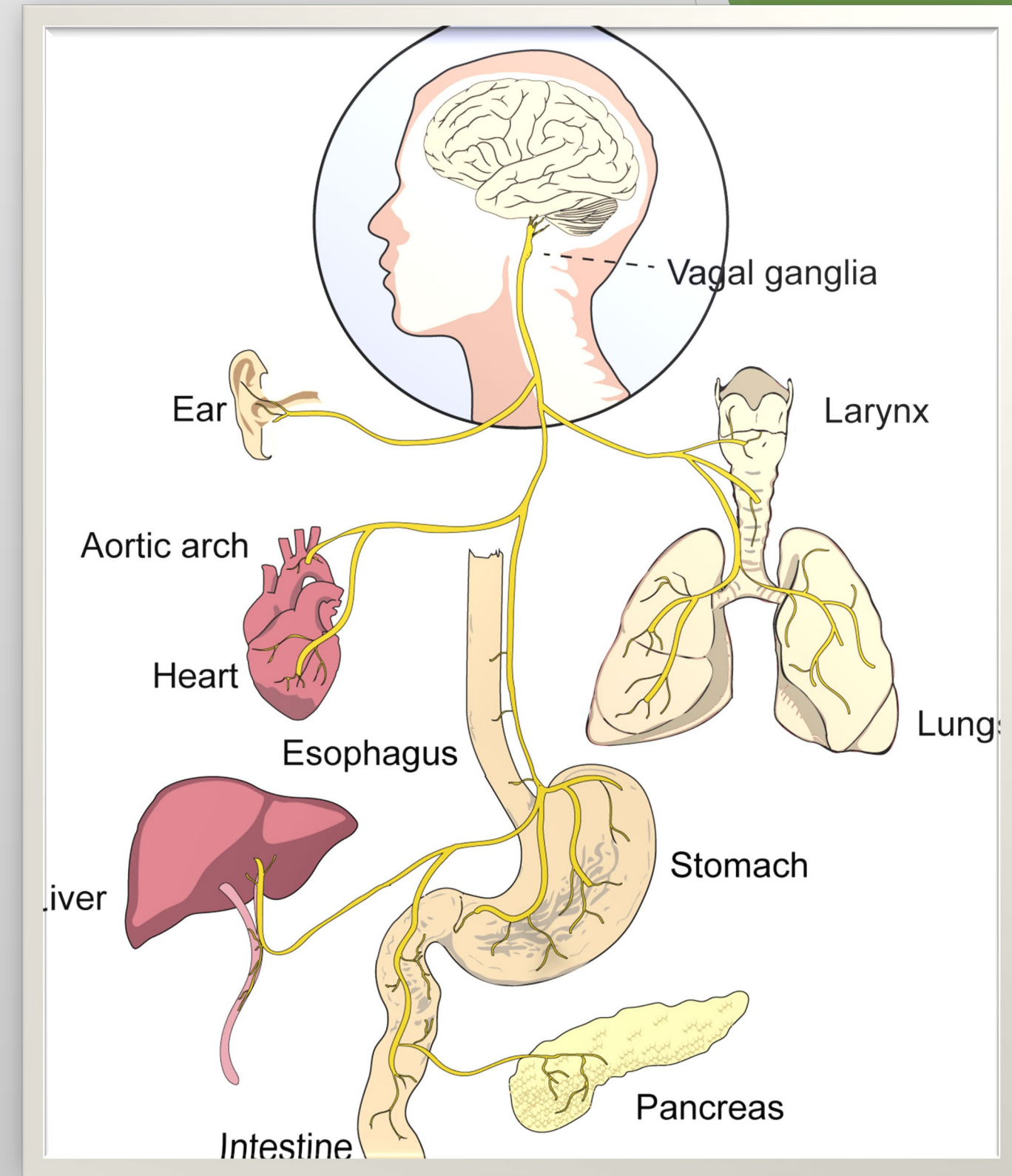


THE VAGUS NERVE (I)



Neuron (Brain cell)

- **VAGUS NERVE:**
 - Connects the **brain to multiple organs**, via neural axons, some 40-60 cm long!
 - Around 200,000 **nerve fibres (axons)** / **neurons** are involved in the human gut-brain vagus nerve.



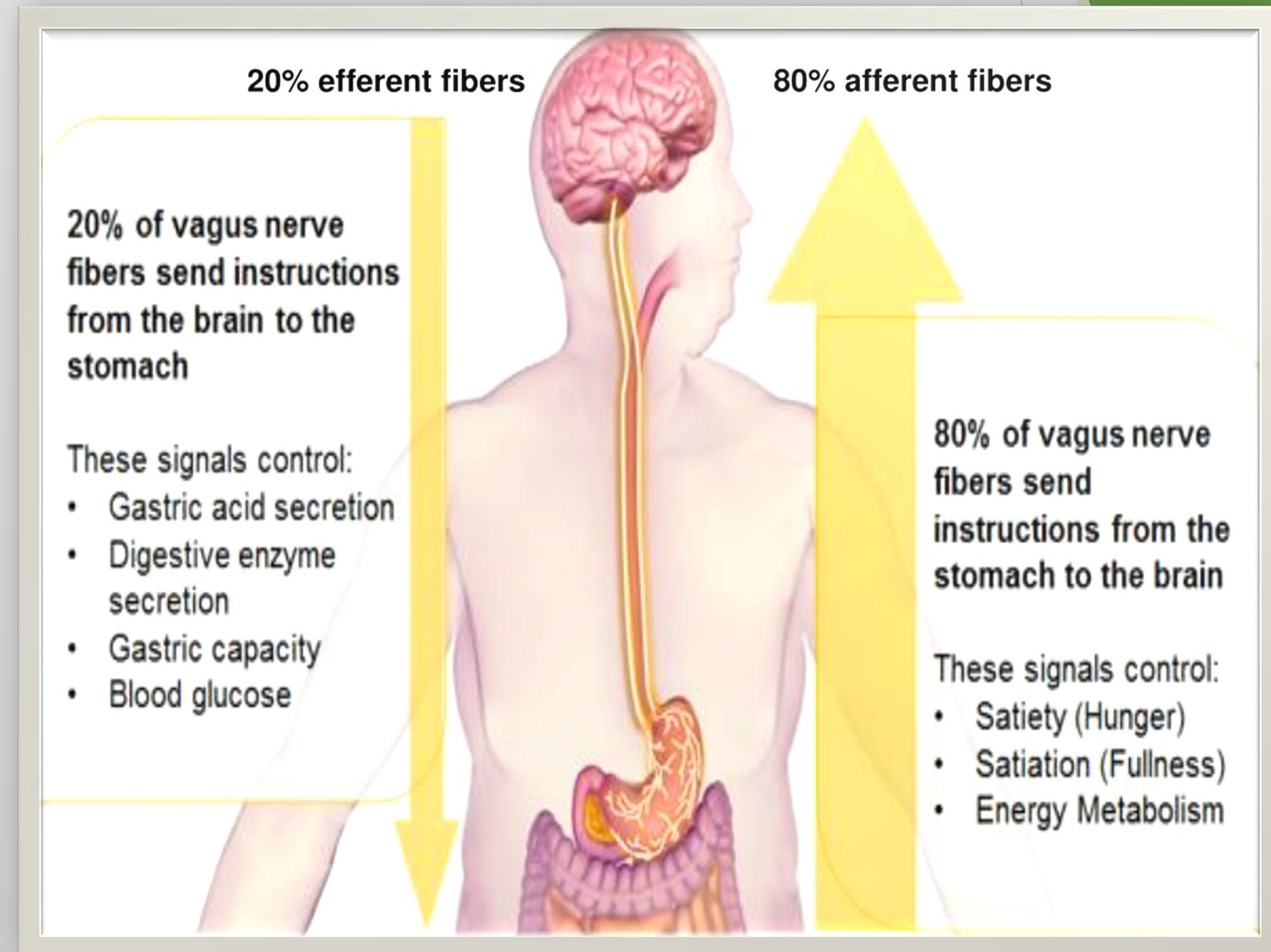
Vagus nerve

THE VAGUS NERVE (II)

THE GUT-BRAIN VAGUS NERVE is like a cable of around 200,000 tiny nerve wires, about 80% of which carry signals from the gut up to the brain.

IT ENABLES:

- Bidirectional messaging between the gut & the brain via a complex variety of mechanisms:
 - Direct messaging from the stomach
 - Largely indirect messaging from the colon (eg via the enteric nervous system)
 - “Encoded” electrical pulses (a type of ‘morse code’) are transmitted UP the vagus nerve and are interpreted by the brain
 - Brain sends instructions to the stomach back DOWN the vagus nerve - e.g. secrete gastric acid and digestive enzyme, if the stomach is full



DISTURBANCE OF MICROBIOME - DYSBIOSIS

GUT DYSBIOSIS

CAUSES AND RESULTING DISEASES

CAUSES

- Diet, drugs, infection, inflammation etc change the colonic environment from low-oxygen, friendly species, to;
- Oxygen-loving, inflammatory species



DISEASES

Dysbiosis is main/major cause:

- Inflammatory Bowel Disease (IBD)
- Irritable Bowel Syndrome (IBS)
- *Clostridioides difficile* infection (antibiotic induced)
- Chronic infectious colitis
- Colorectal cancer

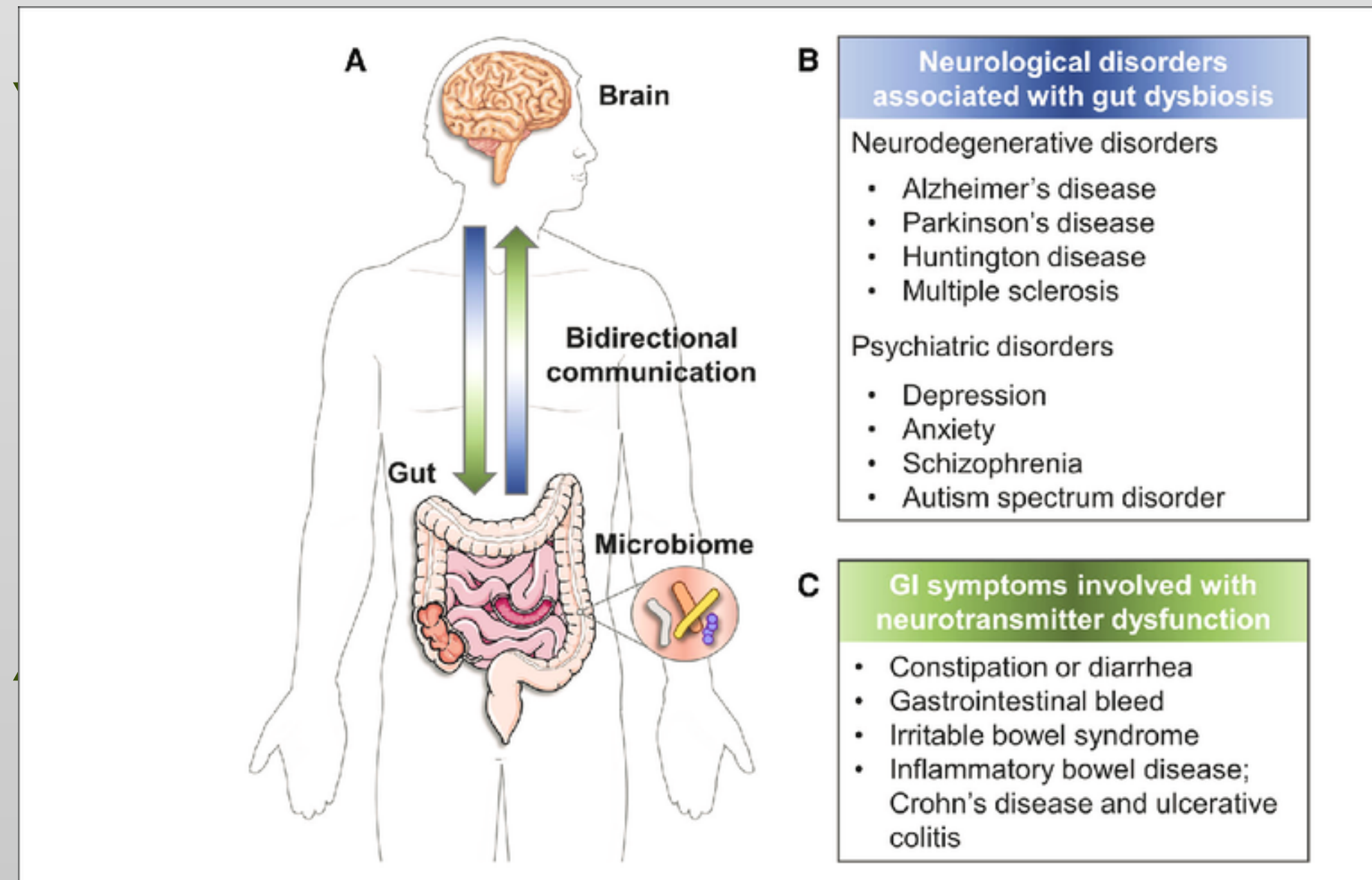
Dysbiosis contributes to disease:

- Obesity
- Type-2 diabetes
- Non-alcoholic fatty liver disease (NAFLD)
- Cardiovascular disease (some forms)

ASSOCIATION BETWEEN GUT DYSBIOSIS & BRAIN DISORDERS

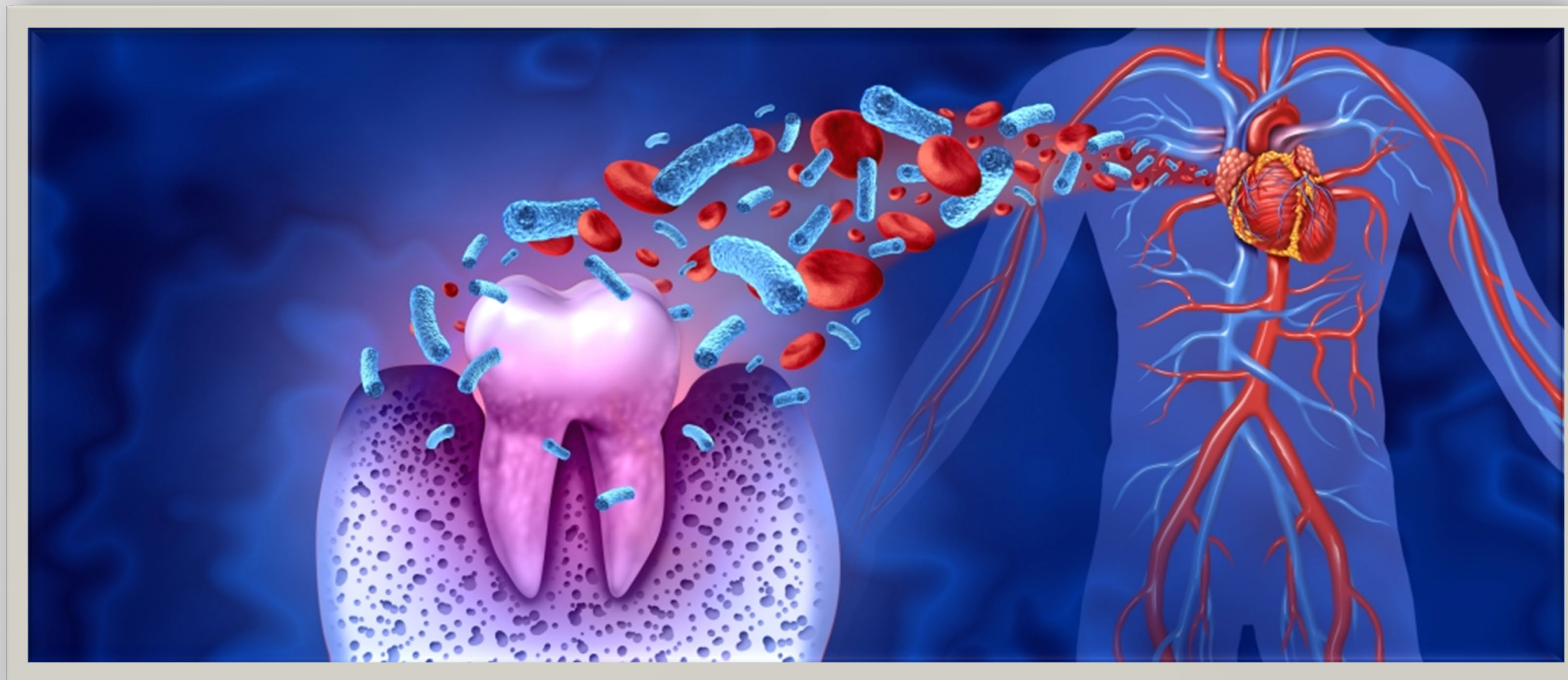
Gut dysbiosis possibly modulates the severity of brain disorders via the gut-liver-brain axis.

However, further research is required to confirm the nature and impact of dysbiosis



THE ORAL CAVITY:GUT:HEART AXIS

THE DEADLY CONNECTION BETWEEN GUM AND CARDIOVASCULAR DISEASE



Unhealthy gums don't just stay in the mouth - they can disturb the gut, send out bacterial toxins and harmful metabolites into the bloodstream, and quietly inflame our arteries and heart over many years.

LOOKING AFTER OUR HIDDEN GARDEN

MEDITERRANEAN DIET



MEDITERRANEAN DIET

Plant diversity is paramount: aim for 30 different plants per week

Fibre feeds beneficial bacteria: whole grains, legumes, vegetables, fruits, nuts, and seeds

Fermented foods add live microbes: include yogurt, kefir, kimchi etc, daily

Oily fish: salmon, mackerel, sardines, trout or herring: provide high levels of long-chain omega-3 fatty acids, which are linked to increases in SCFA-producing bacteria

Polyphenols (reduce inflammation): berries, olive oil, tea, coffee, dark chocolate, herbs, and spices

Lifestyle matters: adequate sleep (7-9 hours), stress management, and regular exercise

FIBRE-RICH FOOD

- *Fibres* are built from a limited set of sugars (e.g. glucose, galactose, mannose, fructose, arabinose, xylose, rhamnose, fucose) that humans cannot digest
- *Fibre-rich foods* include: lentils, chickpeas, beans, nuts, seeds, fruits, vegetables and whole grain products



THAT'S SHALLOT!!

MANY THANKS FOR YOUR KIND ATTENTION!