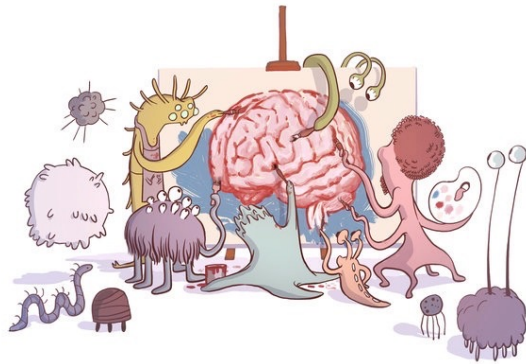


Interactions between the Gut Microbiome and the Brain

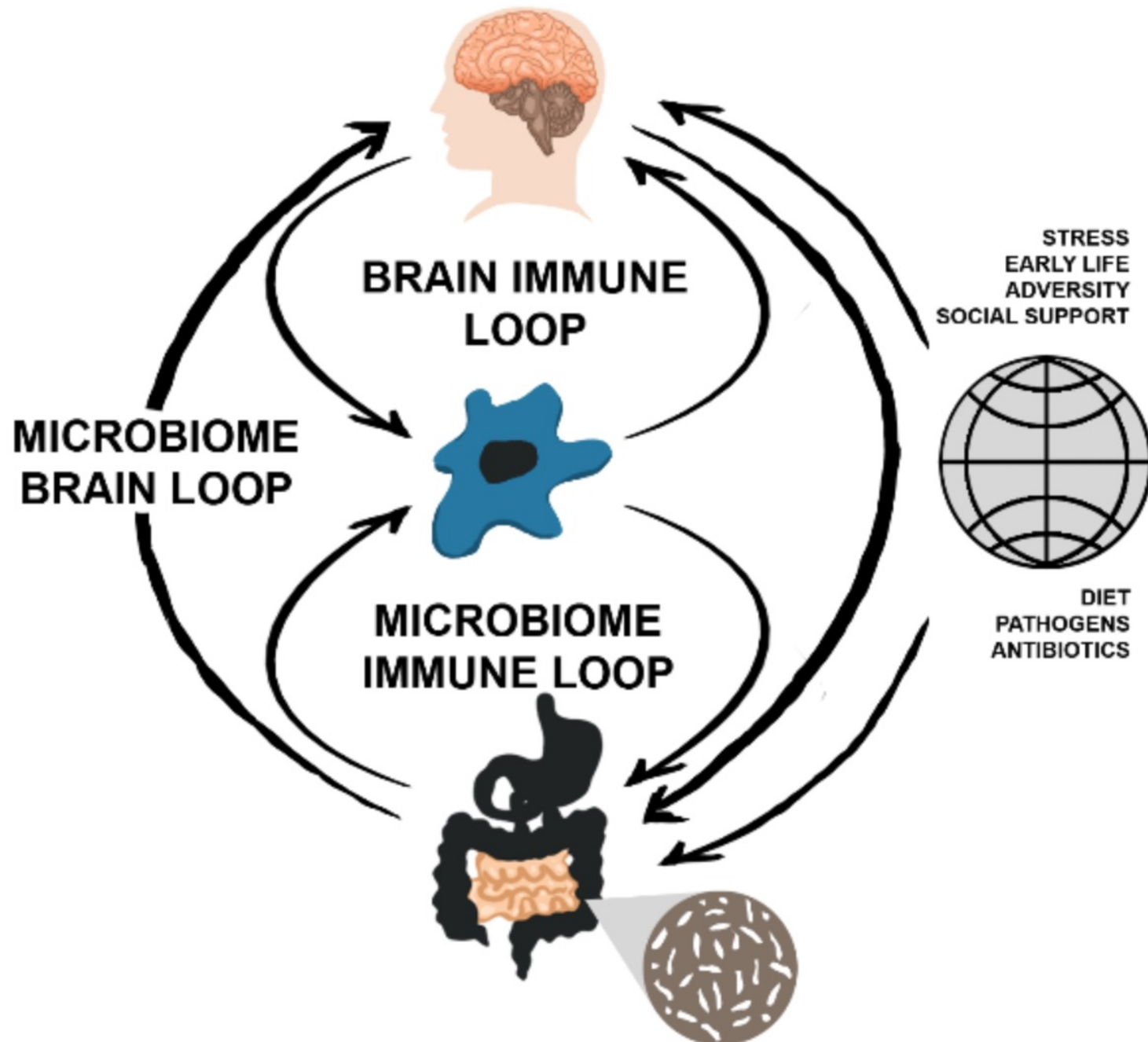
Emeran A. Mayer, MD



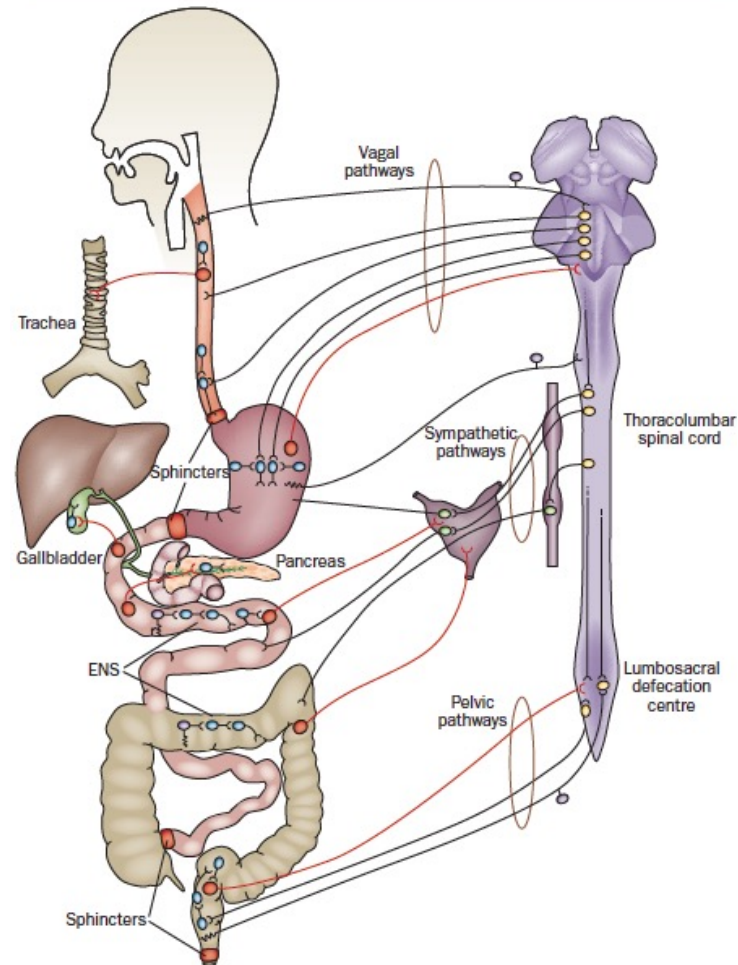
emeranmayer.com
UCLACNS.org



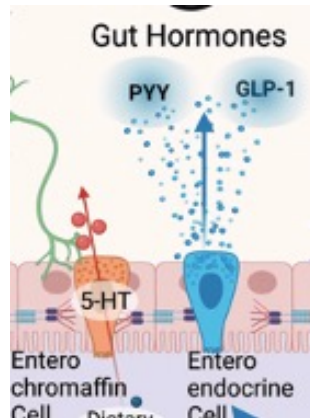
GUT FEELINGS, EMOTIONS, COGNITIONS



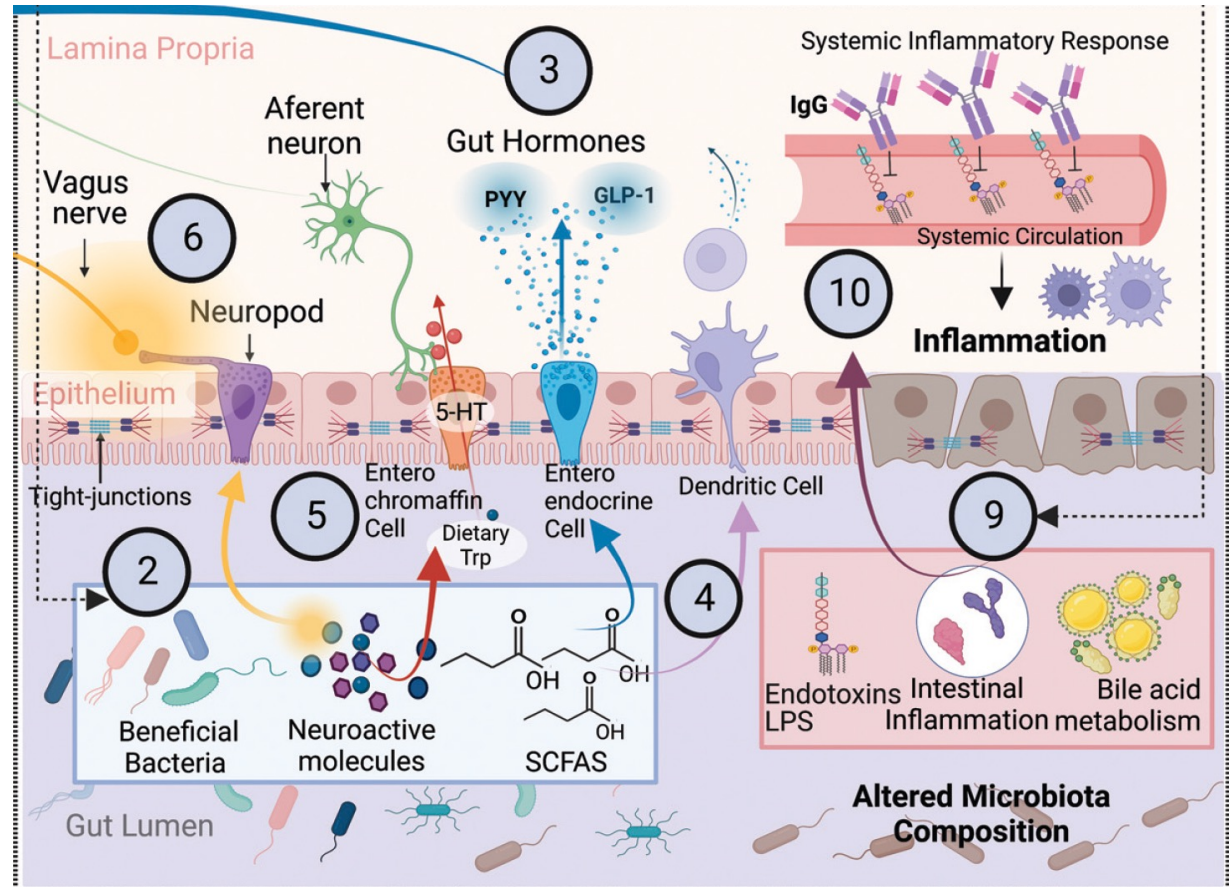
The Gut and the Central Nervous System are Closely Connected



The Gut Connectome – The Second Most Complex Organ in the Body



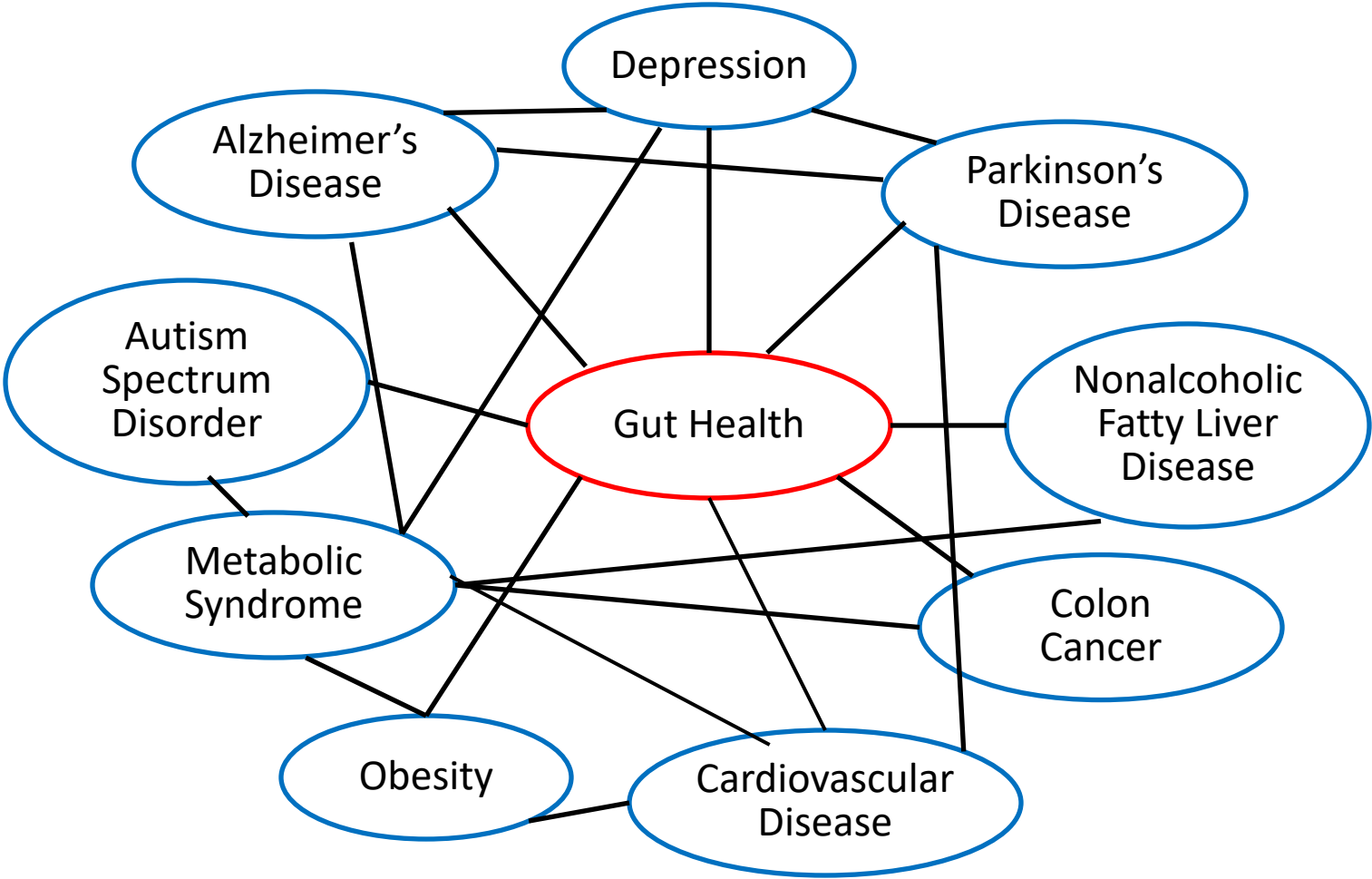
- 70% of immune system
- Enteric nervous system: 150 M neurons
- Glial and epithelial cells
- Extrinsic innervation
- Endocrine system
- Inhabited by 100 T microbes



The Healthy Gut:

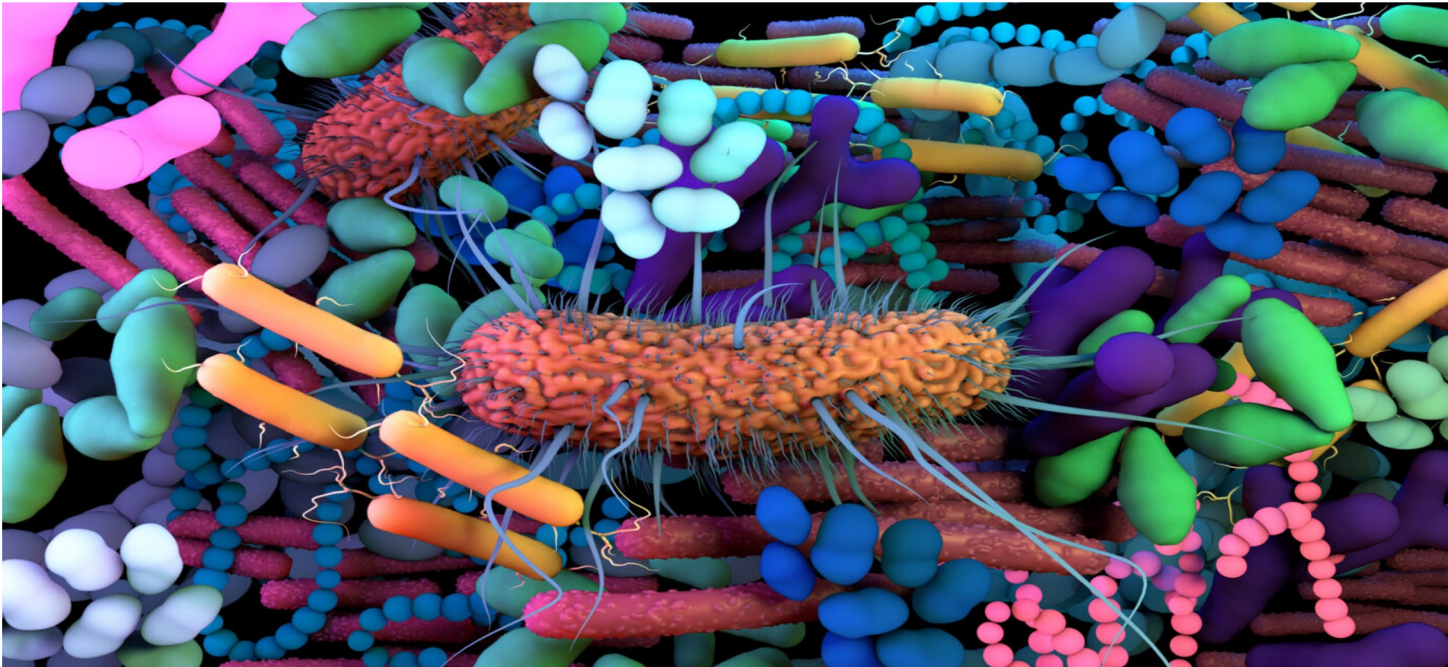
Coordinated interactions of neurons, immune cells, endocrine cells and luminal microbial organisms ("the gut connectome")

Gut Health is at the Center of the Chronic Non-Communicable Disease Network



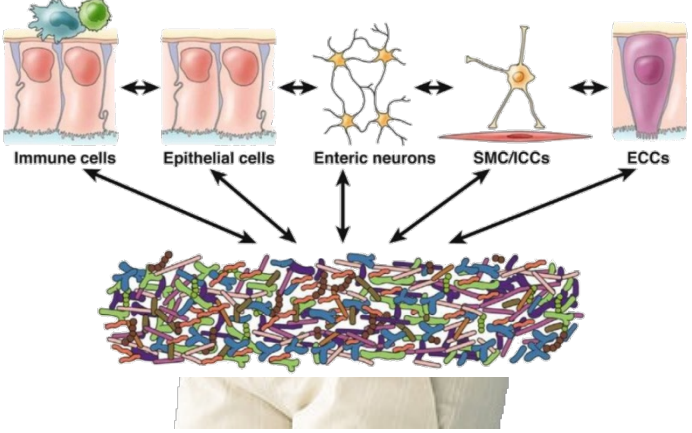
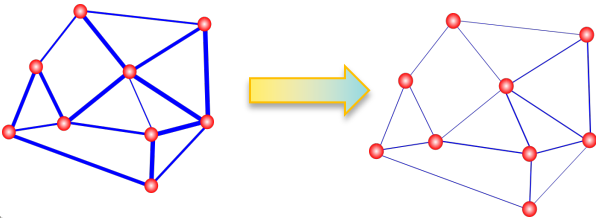
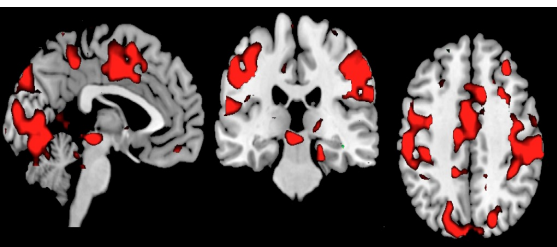
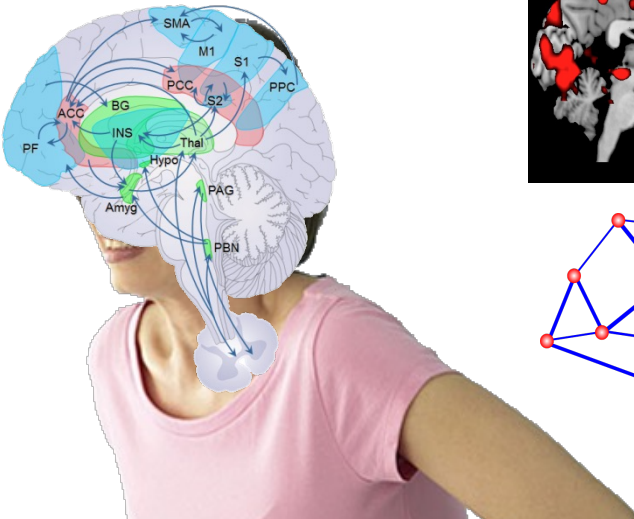
Brain Gut Microbiome 101

The Human Gut Microbiome

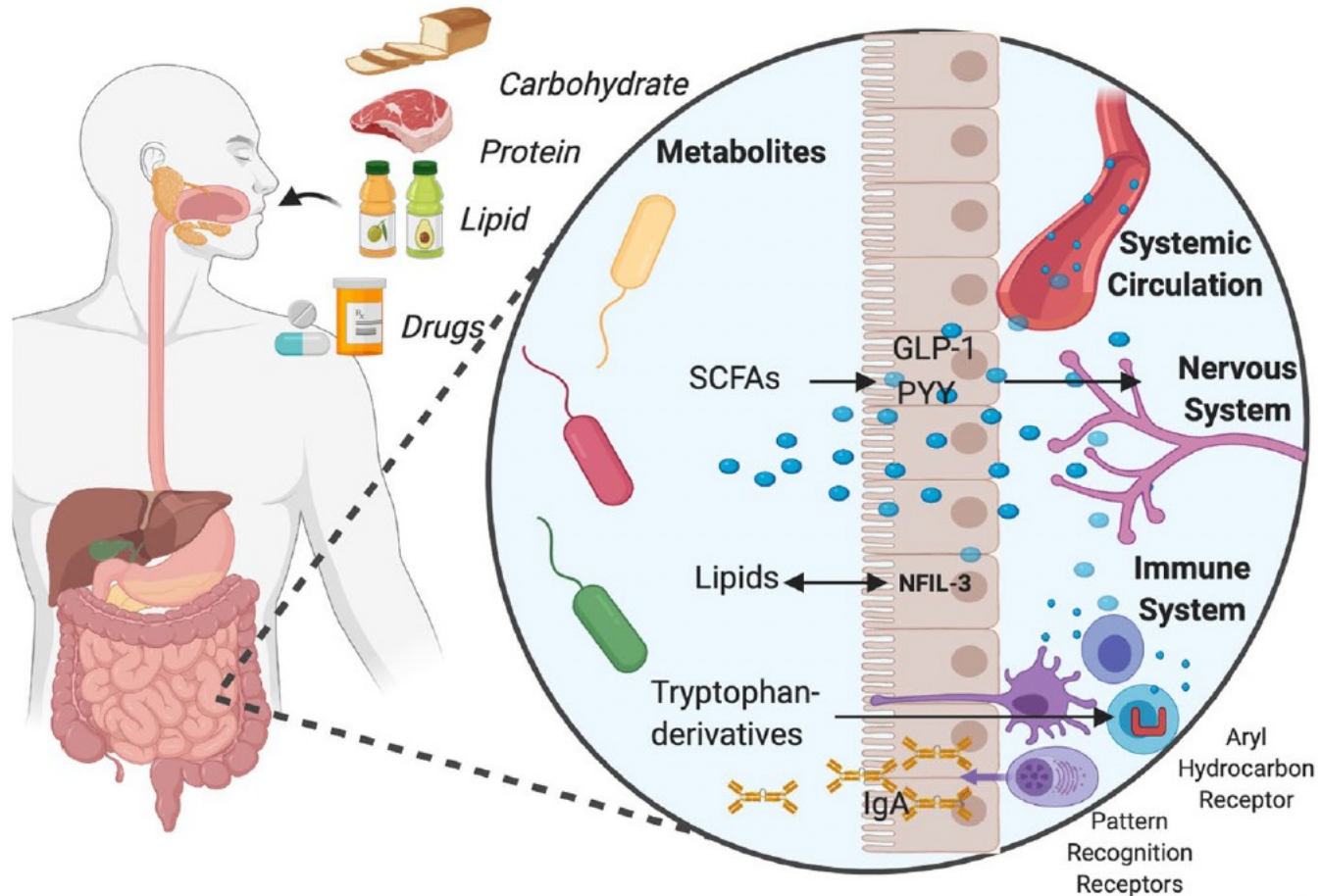


- Highest density of microbes in the human colon
- 100 trillion microorganisms (bacteria, archaea, fungi), 40% of number of human cells; 10x > than neurons in the brain
- Holobiont – Human organism and microbial species have lived in symbiosis for a million years
- Mutually beneficial interactions between host and gut microbiome influence human physiology, metabolism, nutrition and immune function

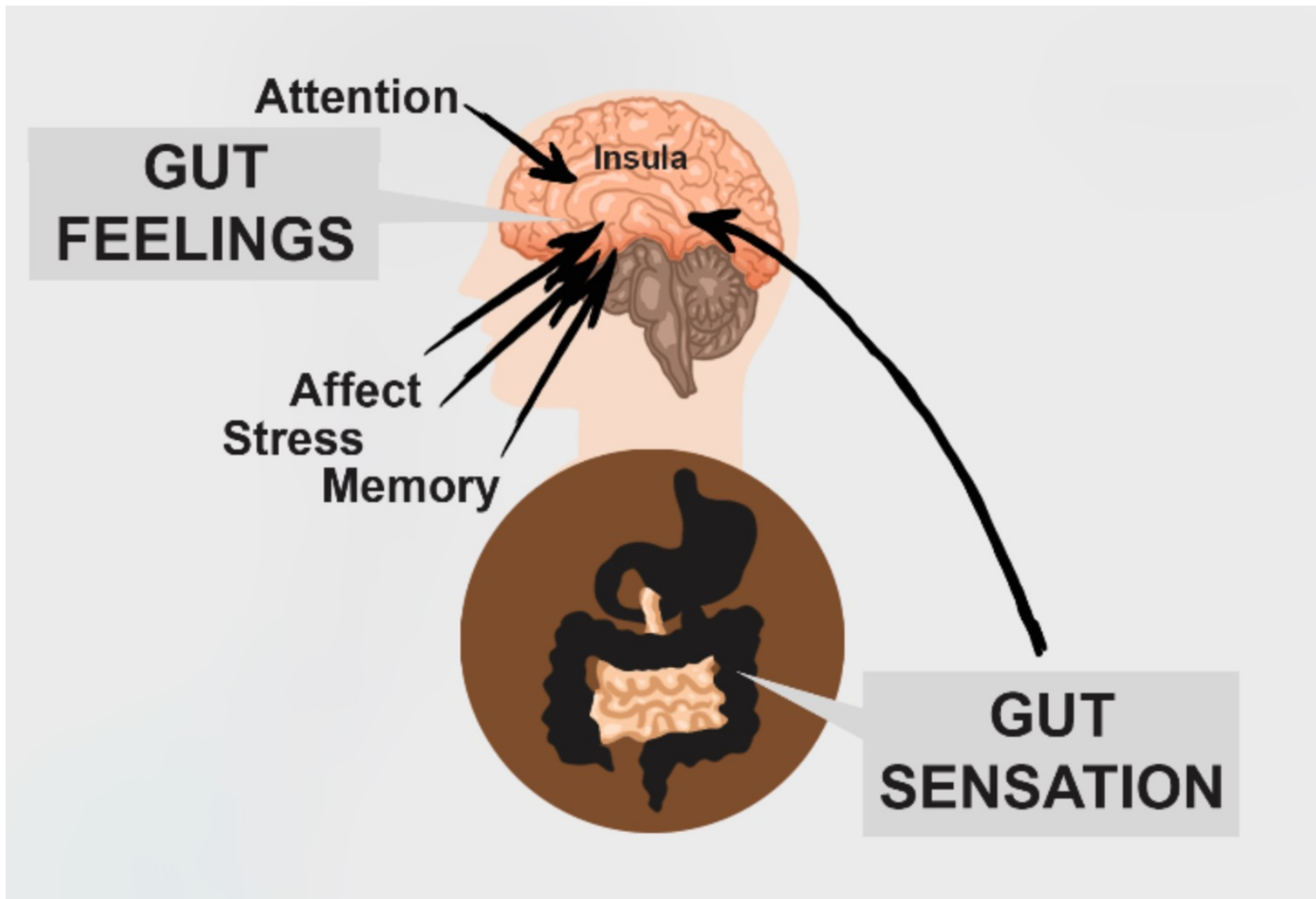
Microbes in the Gut Can Talk to the Brain



Biological Language 2.0: The Microbiome Translates Food Components into Thousands of Biologically Active Metabolites

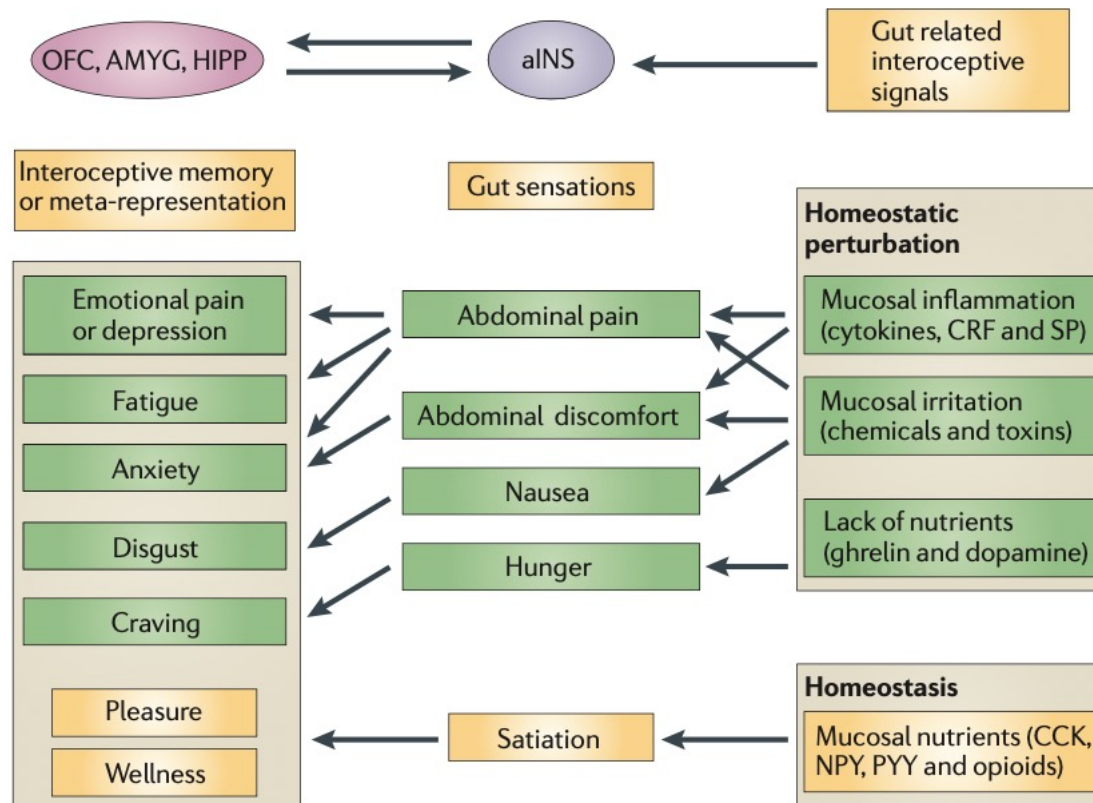


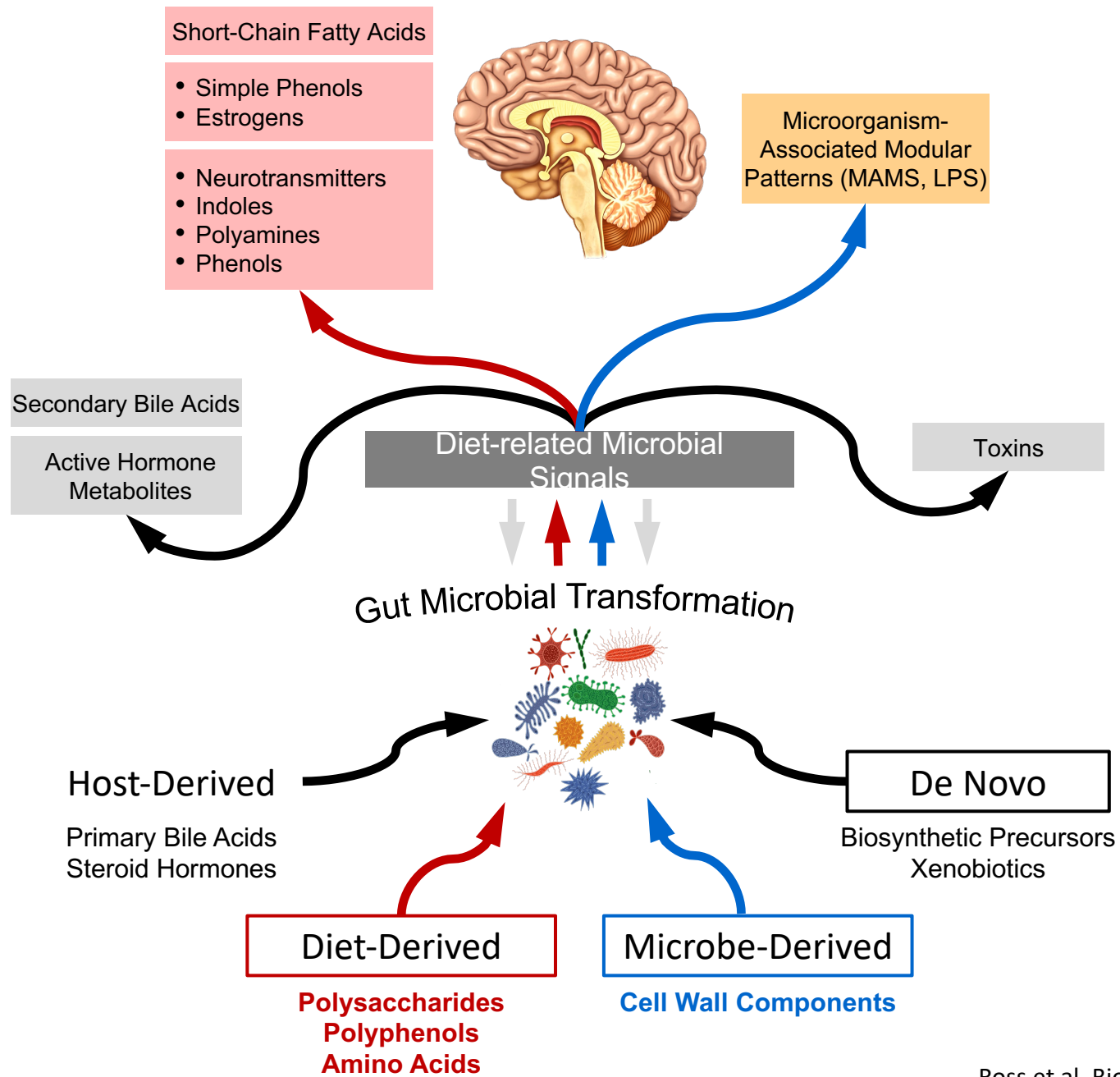
How the Gut talks to the Brain



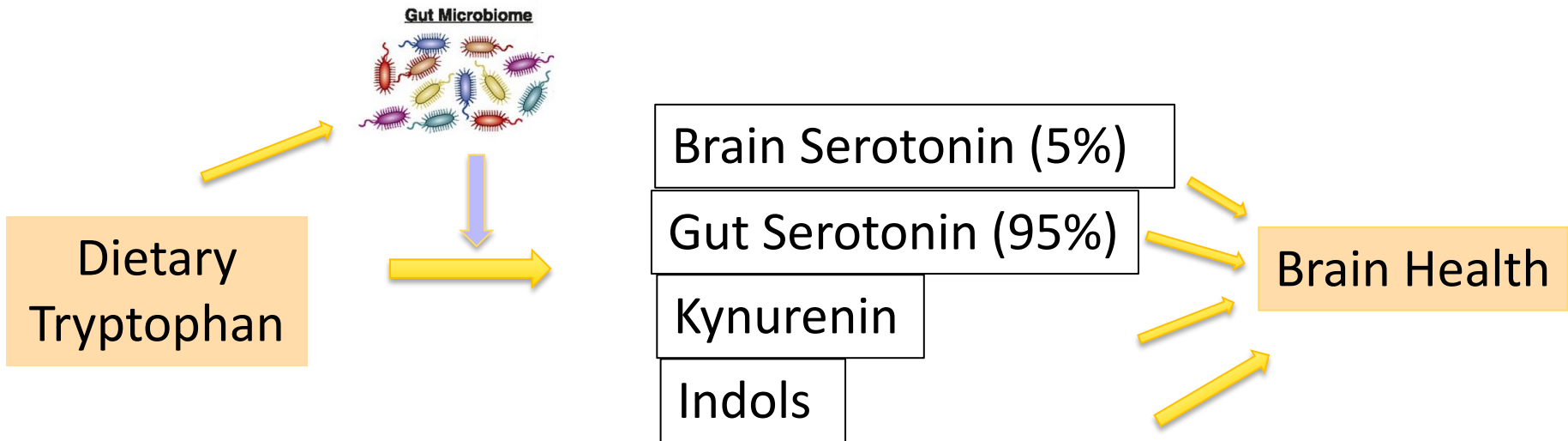
Gut feelings: the emerging biology of gut–brain communication

Emeran A. Mayer

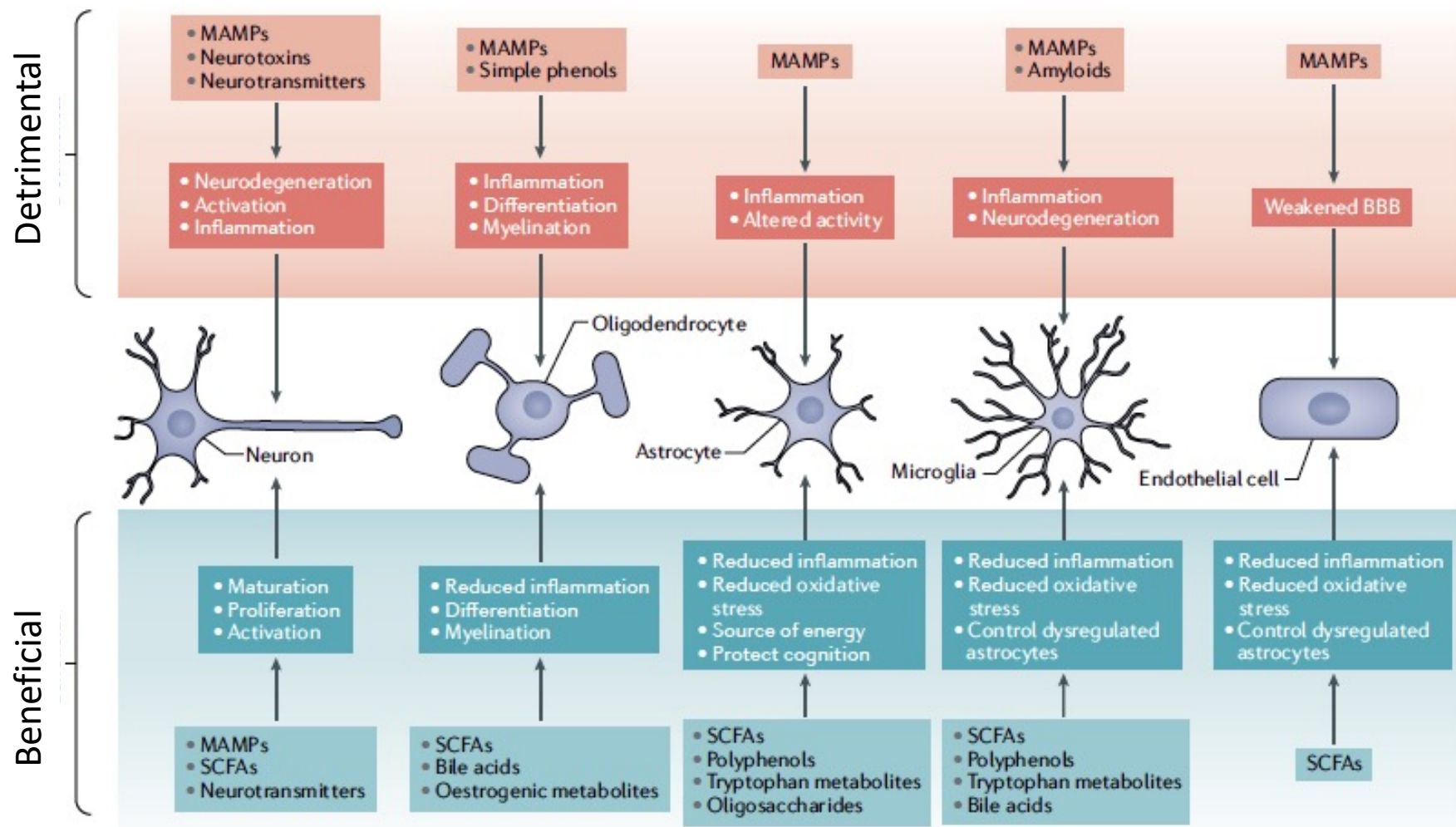




Example Tryptophan: The Microbiome Turns Dietary Tryptophan into Brain Modulating Molecules



The Yin and Yang of Gut Microbe to Brain Signaling - Inflammatory and Antiinflammatory Influences on the Brain

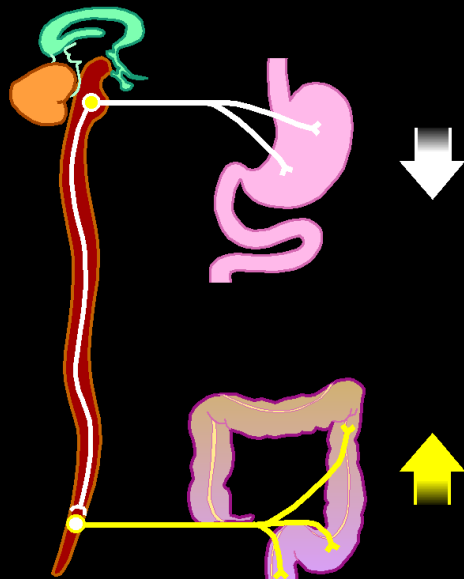


How the Brain talks to the Gut

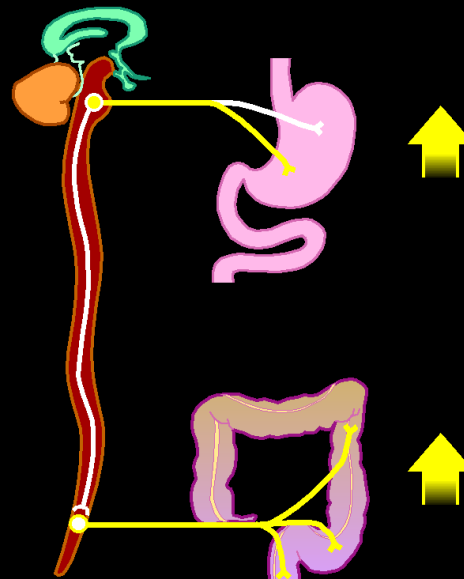
The Brain Talks to the Gut



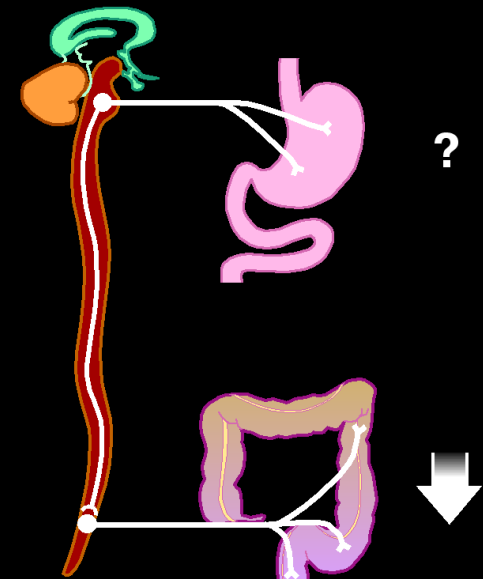
FEAR



ANGER



SADNESS



Stress and Emotion Modulation of Gut Microbial Behavior

Psychosocial
Stress

Anxiety, fear
Anger
Sadness



Stress-induced changes of microbial environment:

- GI motility (regional alterations in intestinal transit)
- Intestinal fluid and mucus secretion (biofilm?)
- Gastric/bile acid secretion
- Paneth cell secretion (antimicrobials)
- **Enteroendocrine cell function**
- Intraintestinal pH
- **Immune modulation**
- Epithelial and blood brain barrier permeability



Rhee et al. NRGH 2009

Stress and Emotion Modulation of Gut Microbial Behavior

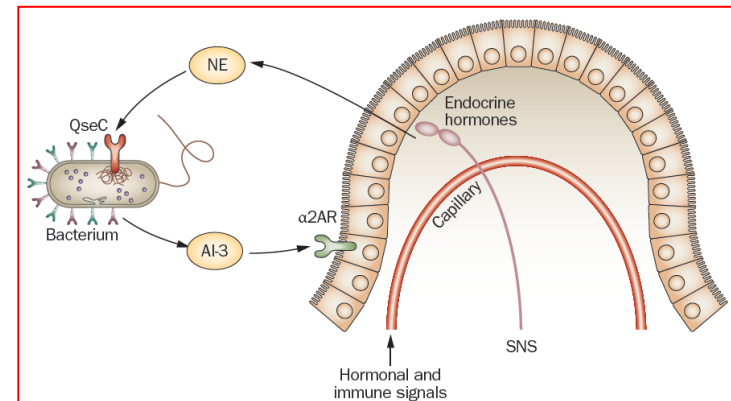
Psychosocial
Stress

Anxiety
Fear
Anger
Sadness



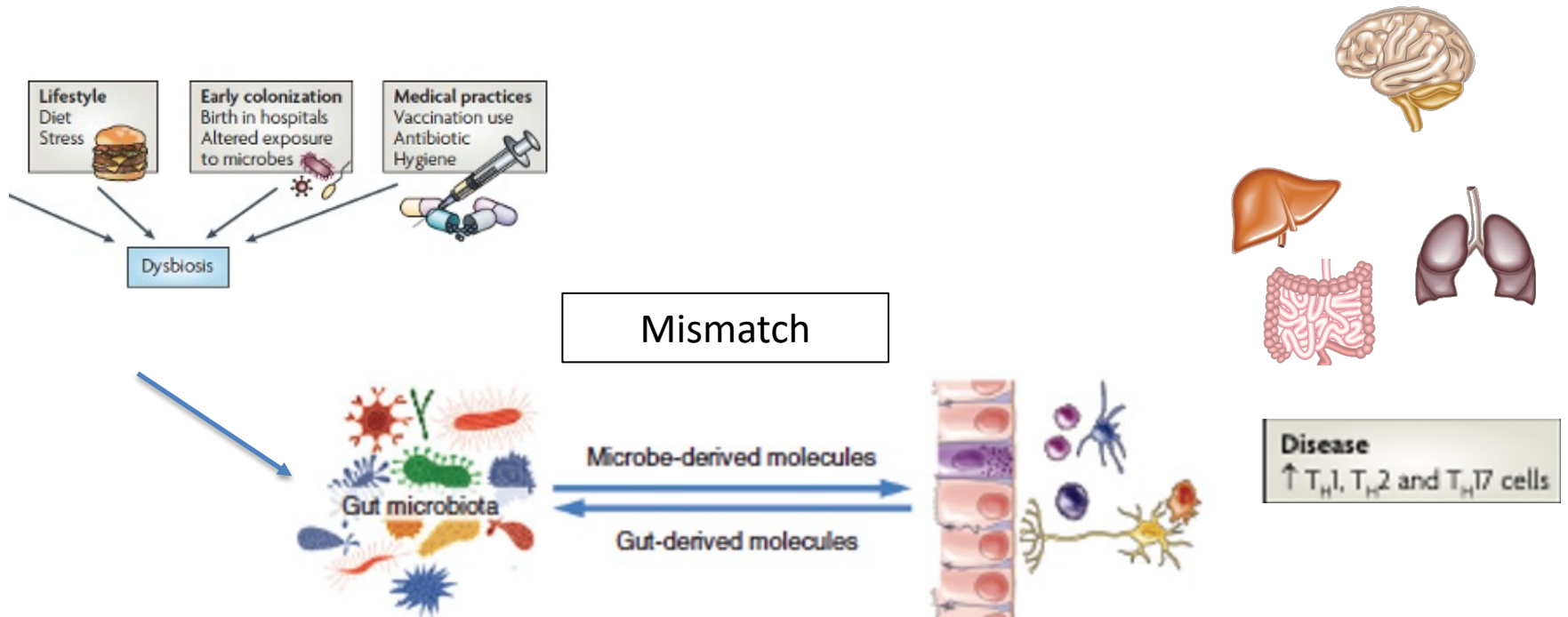
Direct stress-induced effects on microbiota:

- Noradrenergic signaling
- Stress induced signaling molecules released into gut lumen (5-HT, opioids, others?)



The Influence of Lifestyle on BGM Interactions

Poor Gut Health Can Have Widespread Effects on the Body



Immune system activation, metabolic endotoxemia; disease in vulnerable individuals

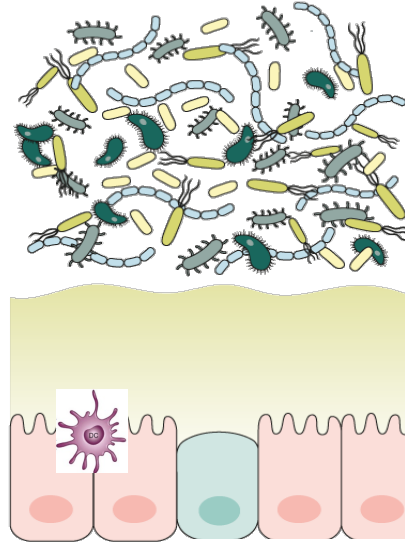
Healthy Diet

- Complex carbohydrates
- High fiber
- ↑ Fiber degradation
- ↑ Gut microbiome diversity
- ↑ Abundance of mucus-stimulating microorganisms
- ↑ Prevotella abundance

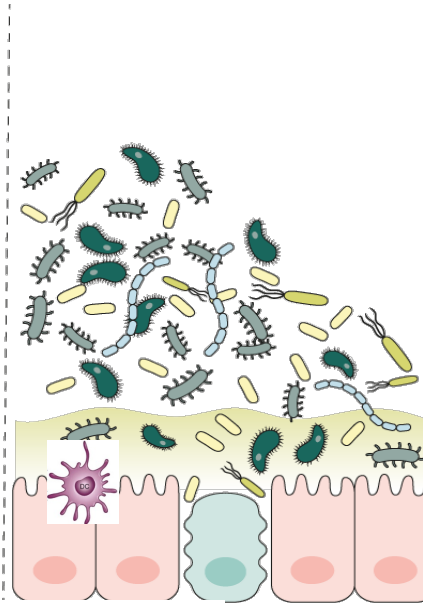
↑ Mucus thickness

Intact gut barrier

Healthy Gut



“Leaky” Gut



Chronic Stress

Western diet

- Refined carbohydrates, sugar
- High fat
- Low fiber
- ↓ Fiber degradation
- ↓ Gut microbiome diversity
- ↓ Abundance of mucus-stimulating microorganisms
- ↓ Prevotella abundance

↓ Mucus thickness

↓ Gut barrier

- Metabolic endotoxemia

Increased genetic risk

Depression

NAFLD

Colon cancer

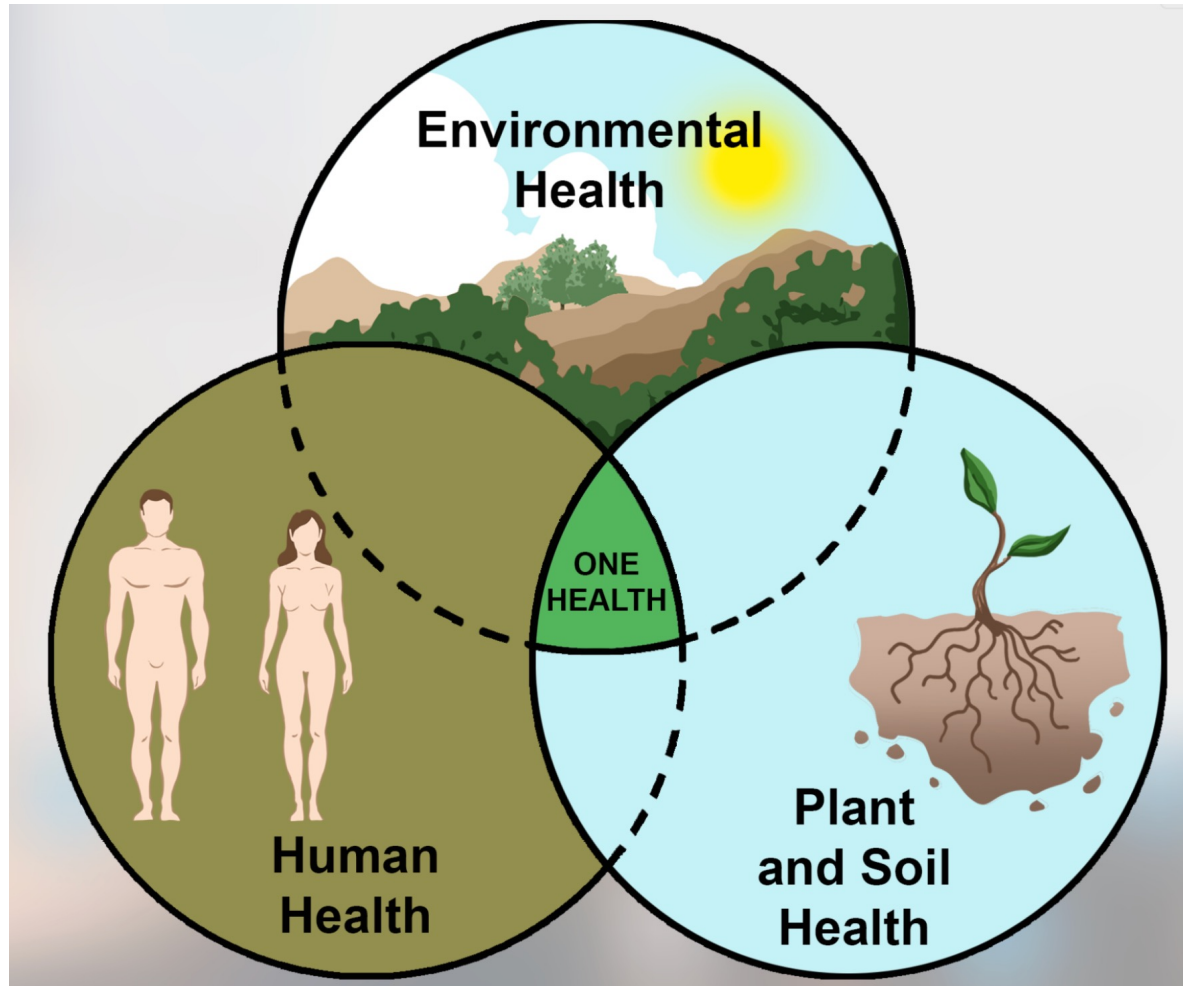
Cognitive decline (AD)

Parkinson’s Disease

Metabolic syndrome

Diet and BGM Interactions

What is the Relationship Between Gut Health & the Health of the Planet?



Is Microbiome Science Causing a Fundamental Transformation of Our View of Health and Wellness?



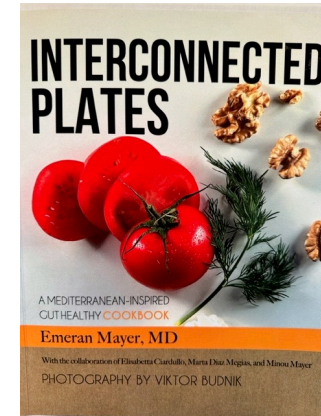
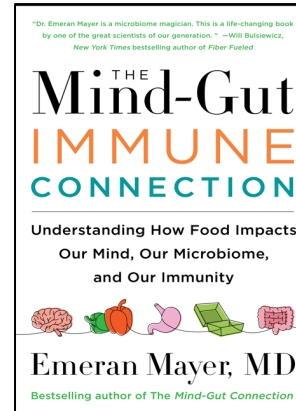
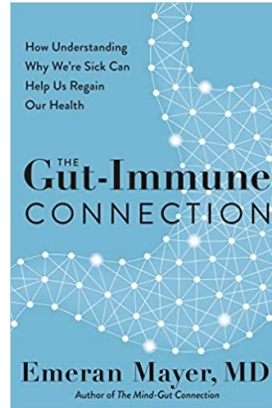
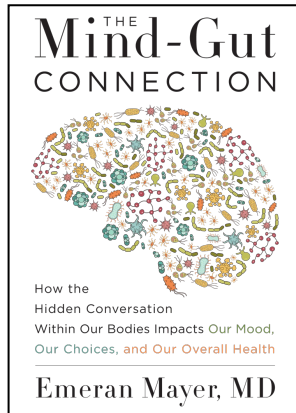
Science is a series of peaceful interludes punctuated by intellectually violent revolutions ... in each of which one conceptual world view is replaced by another..

The Structure of Scientific Revolutions,
Thomas S. Kuhn, 1962



Courtesy of E.
Schadt

Thank You!



Learn much more about Brain Gut Microbiome Immune Interactions at:

emeranmayer.com

Sign up for:

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