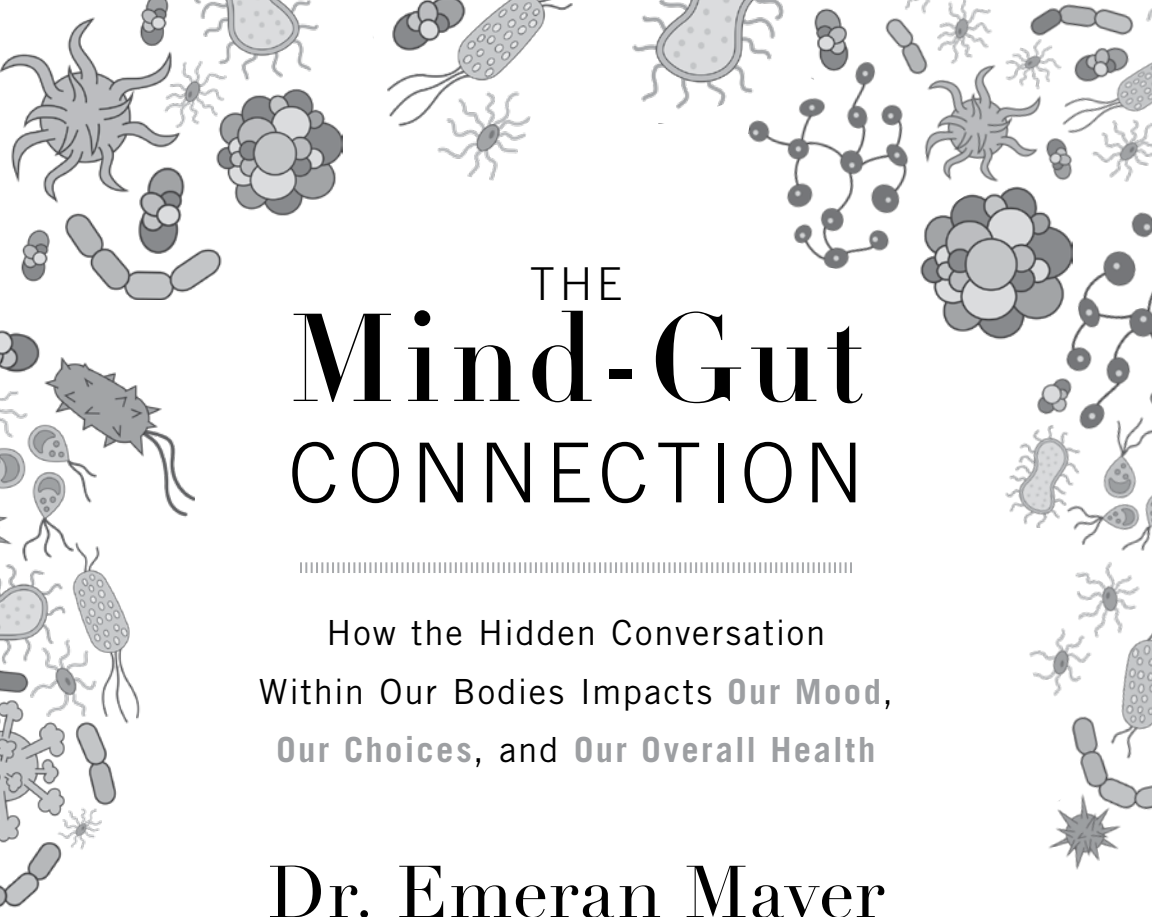

THE Mind-Gut CONNECTION

How the Hidden Conversation Within Our Bodies Impacts **Our Mood**, **Our Choices**, and **Our Overall Health**

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FIG. 1. BIDIRECTIONAL COMMUNICATIONS BETWEEN THE GUT AND THE BRAIN

The gut and the brain are closely linked through bidirectional signaling pathways that include nerves, hormones, and inflammatory molecules. Rich sensory information generated in the gut reaches the brain (gut sensations), and the brain sends signals back to the gut to adjust its function (gut reactions). The close interactions of these pathways play a crucial role in the generation of emotions and in optimal gut function. The two are intricately linked.

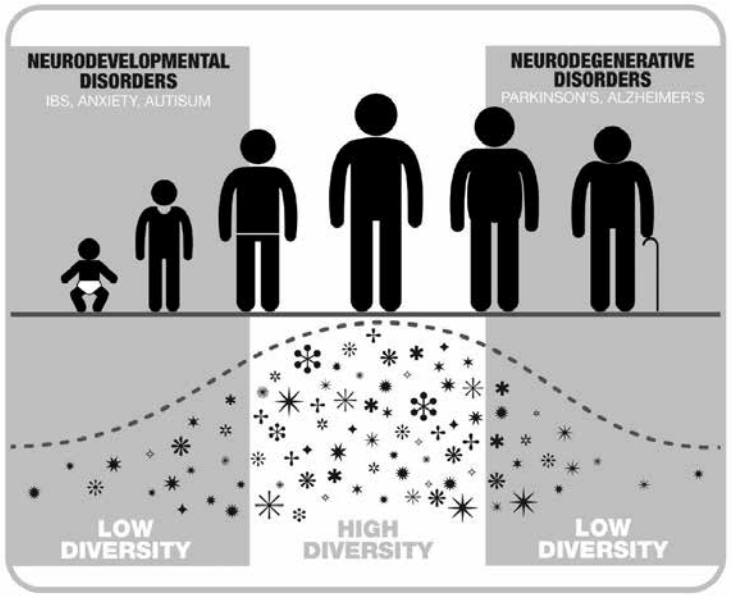

FIG. 2. GUT MICROBIAL DIVERSITY AND VULNERABILITY FOR BRAIN DISORDERS

The diversity and abundance of gut microbes vary over the lifetime of an individual. It is low during the first three years of life when a stable gut microbiome is being established, reaches its maximum during adult life, and decreases as we grow older. The early period of low diversity coincides with the vulnerability window for neurodevelopmental disorders such as autism and anxiety, while the late period of low diversity coincides with the development of neurodegenerative disorders such as Parkinson's and Alzheimer's disease. One may speculate that these low diversity states are risk factors for developing such diseases.

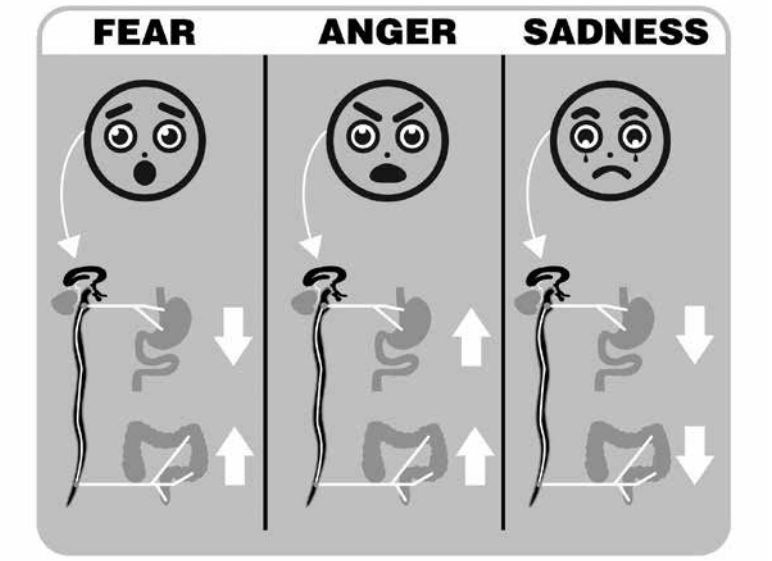

FIG. 3. THE GUT IS A MIRROR IMAGE OF EMOTIONAL FACIAL EXPRESSIONS

Emotions are closely reflected in a person's facial expressions. A similar expression of our emotions occurs in the different regions of the gastrointestinal tract, which is influenced by nerve signals generated in the limbic system. Signals to the upper and lower GI tract can be synchronous or go in opposite directions. Solid white arrows indicate the increase or decrease in gastrointestinal contractions associated with a particular emotion.

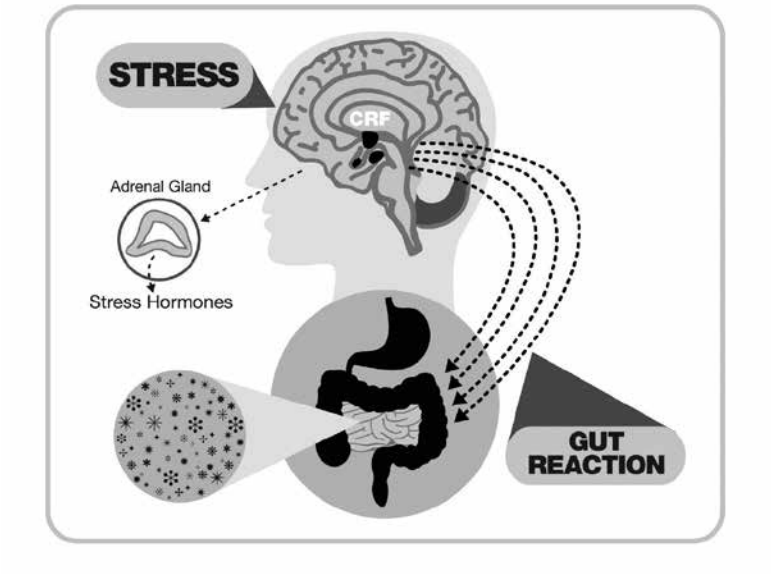

FIG. 4. GUT REACTIONS IN RESPONSE TO STRESS

In response to any perturbations of an individual's normal balanced state such as stress, the brain mounts a coordinated response aimed at optimizing the organism's well-being and survival. The corticotropin releasing factor (CRF) is the chemical master switch that sets this stress response in motion. It is secreted by the hypothalamus and acts on closely adjacent regions of the brain. Stress-induced CRF in the brain is associated with an increase in stress hormones (such as cortisol and norepinephrine) in the body. This process also stimulates a stress-induced gut reaction that impacts the composition and activity of the gut microbiota.

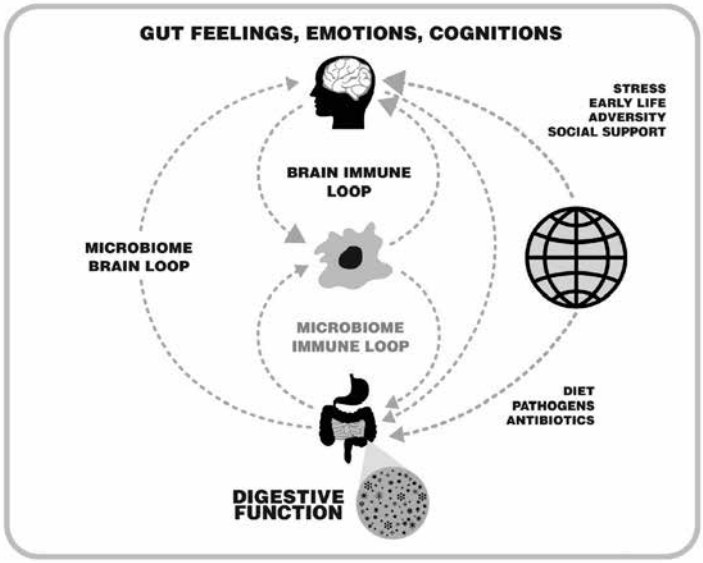

FIG. 5. THE CLOSE LINK OF THE GUT MICROBIOME-BRAIN AXIS WITH THE EXTERNAL WORLD

The gut-brain axis is not only involved in regulatory loops within the body (immune and endocrine systems) but it is also closely linked to the world around us. The brain responds to various psychosocial influences, whereas the gut and its microbiome respond to what we eat, which medications we take, and to any infectious organisms. The entire system functions like a supercomputer which integrates vast amounts of information from within our bodies and from the outside world we live in, to generate optimal digestive and brain functions.

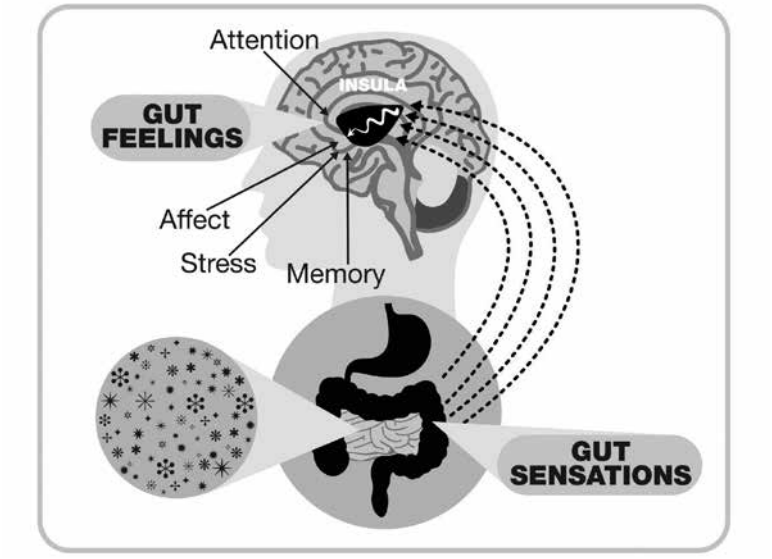

FIG. 6. HOW THE BRAIN CONSTRUCTS GUT FEELINGS FROM GUT SENSATIONS

Signals arising from the gut and its microbiome, including chemical, immune, and mechanical signals, are encoded by a vast array of receptors in the gut wall and sent to the brain via nerve pathways (in particular the vagus nerve) and via the bloodstream. This information in its raw format is received in the back portion of the insular cortex and then processed and integrated with many other brain systems. We only become aware of a small portion of this information in the form of gut feelings. Even though they originate in the gut, gut feelings are created from the integration of many other influences, including memory, attention, and affect.

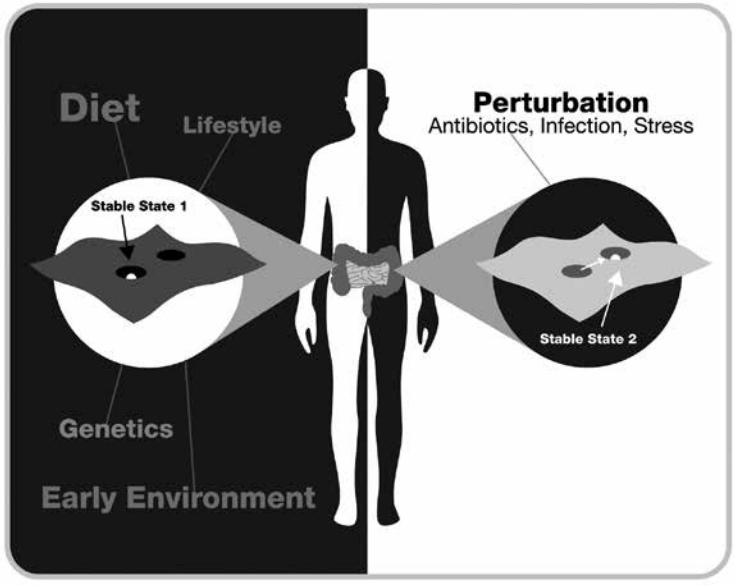

FIG. 7. HOW ANTIBIOTICS, STRESS, AND INFECTIONS CAN CHANGE THE ECOLOGICAL LANDSCAPE OF THE GUT MICROBIOME

Using terminology from ecology, the gut organization and function of the gut microbiome can best be conceptualized as a stability landscape with hills and valleys; the deeper the valleys, the more resistant the state is to perturbations. The stability of the state is determined by a variety of factors including genes and early life events. When the system is perturbed sufficiently, it will leave its original stable state and move to a new state, which can be stable or transient. Many of these new states are associated with disease. The most common perturbations are antibiotics, infections, or stress.

HOW AND WHAT TO FEED YOUR GUT MICROBES

- Aim to maximize gut microbial diversity by maximizing regular intake of naturally fermented foods and probiotics.
- Reduce the inflammatory potential of your gut microbiota by making better nutritional choices.
  - Cut down on animal fat in your diet.
  - Avoid, whenever possible, mass-produced, processed food and select organically grown food.
- Eat smaller servings at meals.
- Be mindful of prenatal nutrition.
- Reduce stress and practice mindfulness.
- Avoid eating when you are stressed, angry, or sad.
- Enjoy the secret pleasures and social aspects of food.
- Become an expert in listening to your gut feelings.