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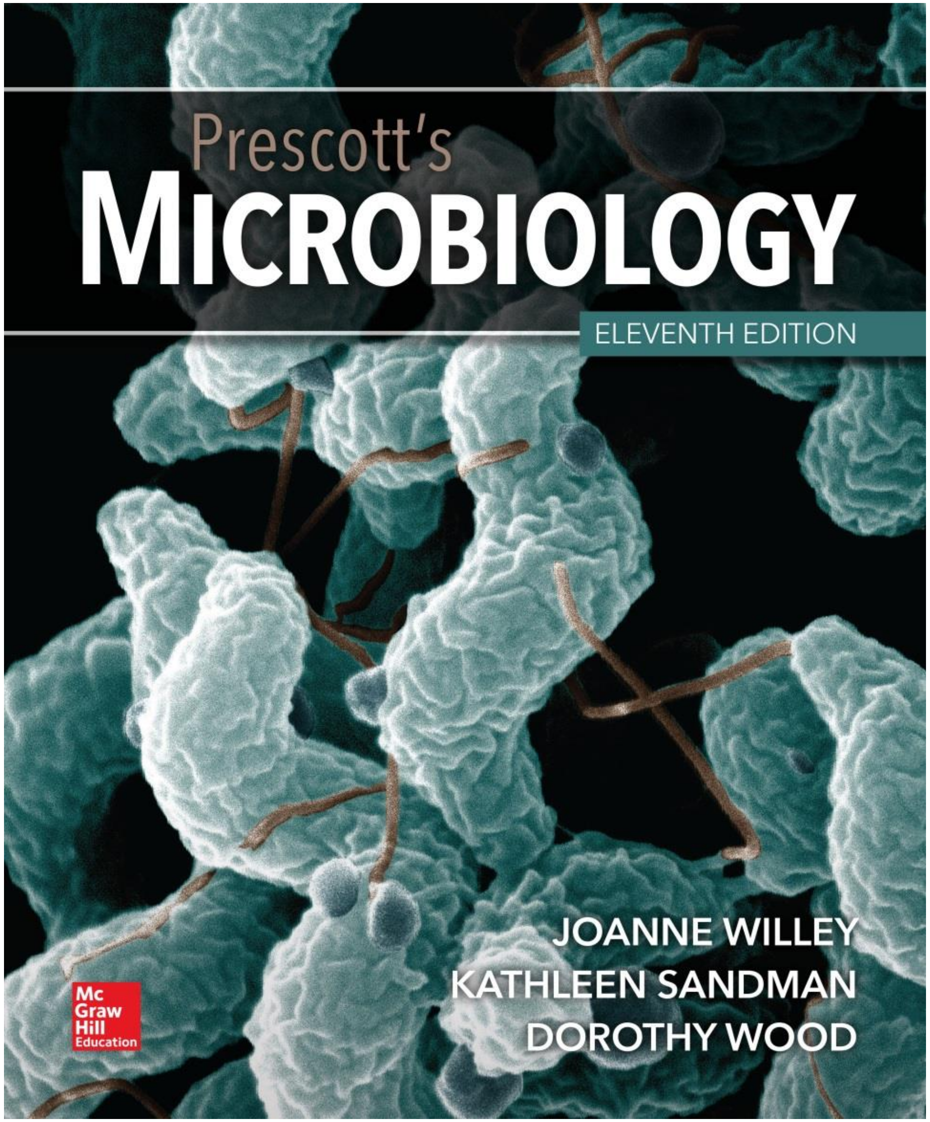

Prescott's
MICROBIOLOGY
ELEVENTH EDITION

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Chapter 34

The Microbe-Human Ecosystem

Terminology

Microbiome—all the microbes "that literally share our body space".

- Each person harbors a unique set of microbes affected by their environment, diet, medications, and other factors.

Holobionts—hosts and microbes live together and evolve together.

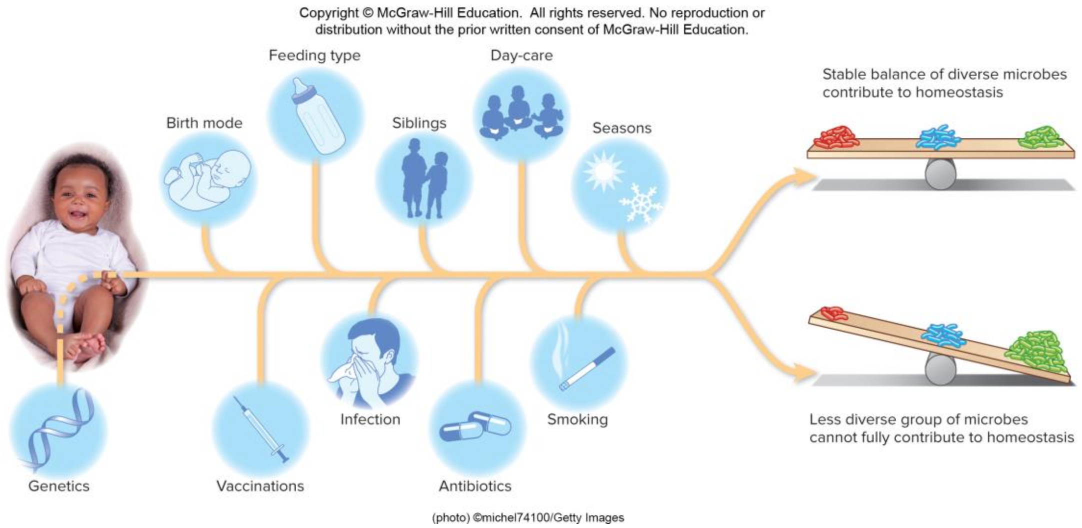
- Humans cannot live a normal life without their microbial partners.

Normal microbiota—microbes commonly associated with the human body.

Development of a Stable Microbiome

Normal community of mutualistic and commensal microbiota begins developing at birth and changes as we age.

- We develop an adultlike community of microbes by age 3.
- It is important to develop a microbiome rich in diversity.



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Early Colonization

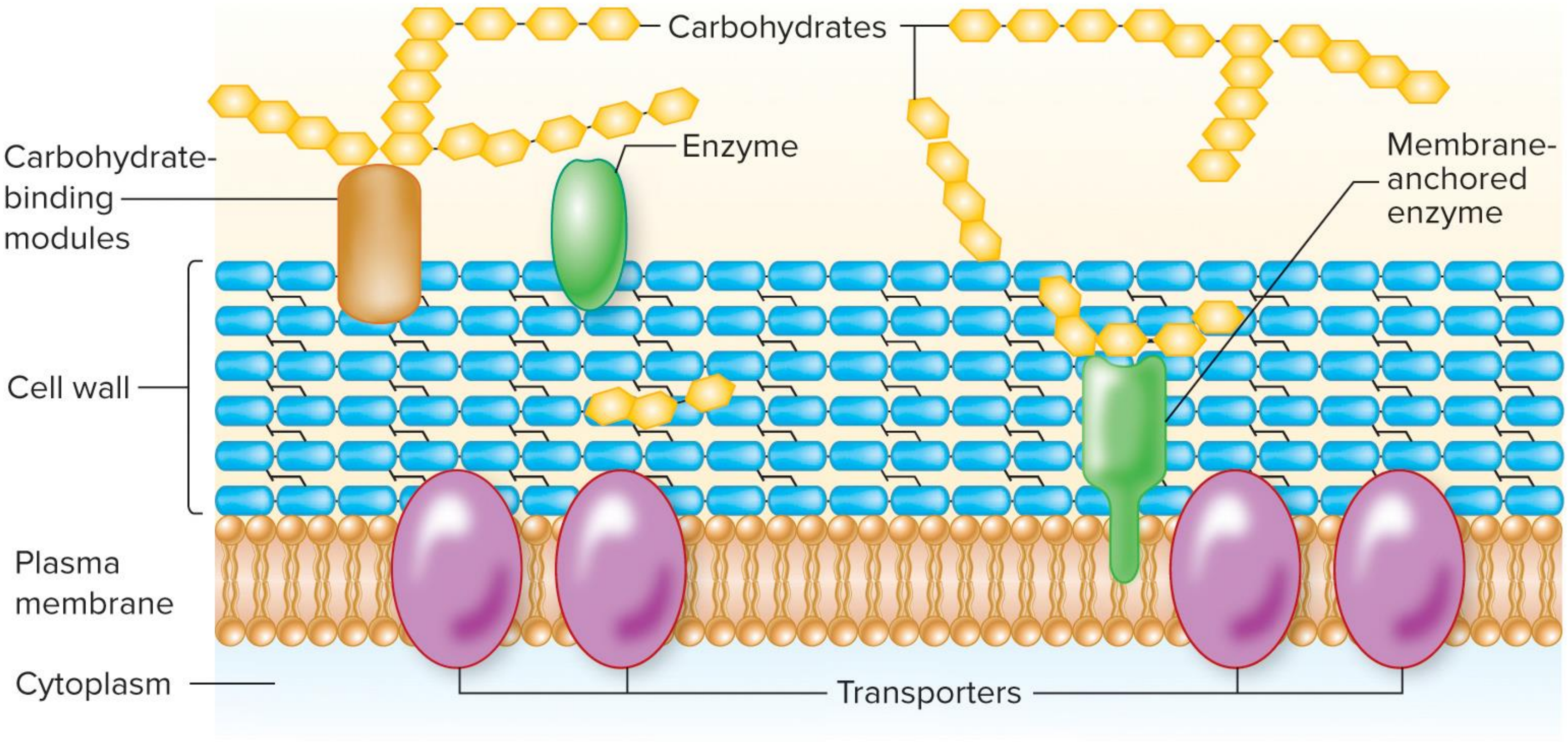
E. coli and streptococci establish a reducing environment in the intestinal tract.

- Allow growth of anaerobes bifidobacteria and bacteriodetes.

Bifidobacteria.

- Found in breastfed babies.
- Can synthesize all amino acids and growth factors from simple carbohydrates.
- Have surface proteins that can bind sugars—fermentation of these sugars provides the infant with calories and lowers the gut pH, limiting growth of certain pathogens.

Sugar Acquisition Strategy of Bifidobacteria



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Adult Human Microbiota

Relatively stable over time.

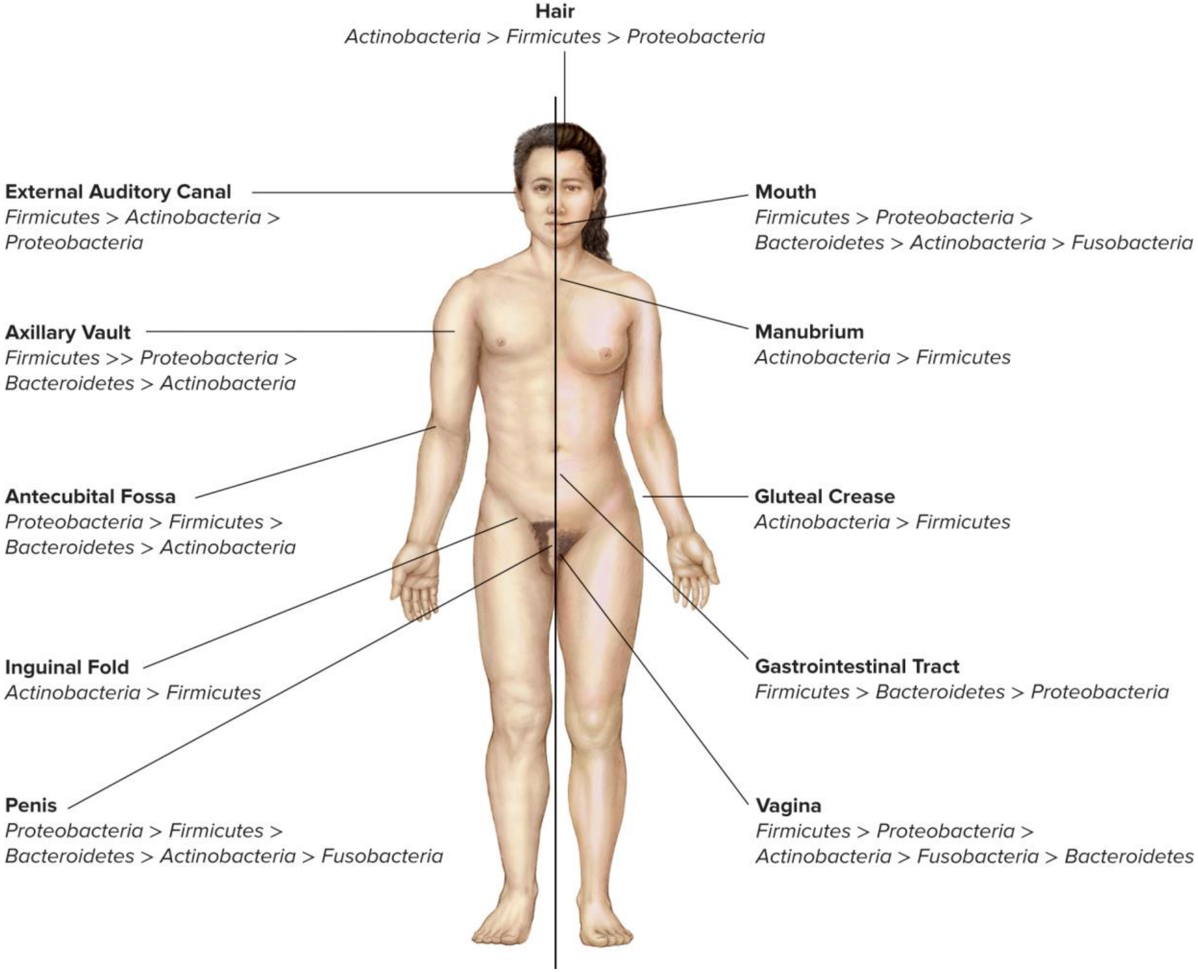
Highly variable from person to person and at different sites within the same person.

Bacteria common to human skin, the intestinal tract, and the other mucosal surfaces include five major phyla:

- *Actinobacteria.*
- *Bacteroidetes.*
- *Firmicutes.*
- *Fusobacteria.*
- *Proteobacteria.*

A number of archaea, fungi, and viruses are also present.

Relative Areas and Types of Human Microbes



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The Microbiome Varies by Body Site

Internal tissues (For example, brain, blood, cerebrospinal fluid, muscles) are normally free of microorganisms.

Surface tissues (For example, skin and mucous membranes) are constantly in contact with the environment and are colonized by various microbes.

Skin

Inhospitable environment.

- Slightly acidic pH.
- High concentration of NaCl.
- Many areas low in moisture.
- Oily lubricant sebum and antimicrobial peptides in other areas.

Transient microbes—temporarily present and typically unable to multiply on the skin.

Three environmental niches:

- Dry (greatest microbial diversity).
- Moist.
- Sebaceous (containing sebum; lowest microbial diversity).

Respiratory Tract

Upper respiratory tract—nostrils, sinuses, pharynx, and oropharynx.

- Colonized by a diverse group of microbes.

Lower respiratory tract—larynx below the vocal cords, trachea, bronchi, and lungs.

- Not sterile as previously thought.

Eye and External Ear

Eye.

- From birth throughout a human life, small numbers of bacteria are found on the conjunctiva of the eye.
- The predominant bacterium is *Staphylococcus epidermidis*.

External ear.

- Similar to skin flora, with coagulase-negative staphylococci and *Corynebacterium* spp. Predominating.

Mouth

Within hours of birth, the oral cavity is colonized by microorganisms from the surrounding environment.

Anaerobes (*Porphyromonas, Prevotella,* and *Fusobacterium* spp.) become dominant due to the anoxic nature of the space between the teeth and gums.

As teeth grow, *Streptococcus parasanguis* and *S. mutans* attach to enamel surfaces; *S. salivarius* attaches to the buccal (For example, inside the cheeks) and gum epithelial surfaces and colonizes the saliva.

- Produce a glycocalyx and various other adherence factors that enable them to attach to oral surfaces; contribute to formation of dental plaque, caries, gingivitis, and periodontal disease.

Stomach

Most microbes killed by acidic conditions.

- *Streptococcus, Staphylococcus, Lactobacillus, Peptostreptococcus* spp., and yeasts such as *Candida* spp. can survive in gastric fluid.

Some microorganisms may survive:

- If pass through stomach very quickly.
- If ingested with food particles and are resistant to gastric pH.

Small Intestine

Divided into three areas:

- Duodenum—contains few organisms due to stomach acid, bile, and pancreatic secretions; Gram-positive cocci and rods comprise most of the microbiota.
- Jejunum—*Enterococcus faecalis*, lactobacilli, diphtheroids, and the yeast *Candida albicans* occasionally found.
- Ileum—flora present becoming similar to that in colon; pH becomes more alkaline; anaerobic Gram-negative bacteria and members of the family *Enterobacteriaceae* become established.

Large Intestine (Colon)

Largest microbial population of body.

Among people living in industrialized nations, genera that appear to be part of the core microbiome include (but certainly are not limited to) *Bacteroides, Faecalibacterium, Clostridia, Prevotella, Coprococcus,* and *Ruminococcus.*

Genitourinary Tract

Kidneys, ureter, and urinary bladder.

- Normally free of microbes.

Distal portions of urethra.

- Few microbes found (*S. epidermidis, E. faecalis,* and *Corynebacterium* spp.).

Female genital tract.

- Complex microbiota in a state of flux due to menstrual cycle.
- Acid-tolerant lactobacilli predominate.

Functional Core Microbiome

Those microbes that provide the host with a suite of activities required for health and homeostasis.

- That is, vitamin K provided by *E. coli.*
- That is, emerging role of gut microbiota in human behavior.

Host Metabolism

We rely on our gut microbiota to convert our food into calories we can use.

Overweight and obese people have higher relative concentrations of gut bacteria belonging to the phylum *Firmicutes* compared to bacteria belonging to the phylum *Bacteroidetes*, along with several other changes in gut microbiota population.

Many bacteria ferment complex polysaccharides into short-chain fatty acids, some of which promote weight gain.

Has refocused attention from the individual species that constitute the gut microbiome to the metabolome (products these microorganisms secrete).

Germ-Free (GF) Mice

Born by cesarean section, raised in sterility.

Can be used to study effects of microbes on animal health by comparing germ-free animals to normal animals.

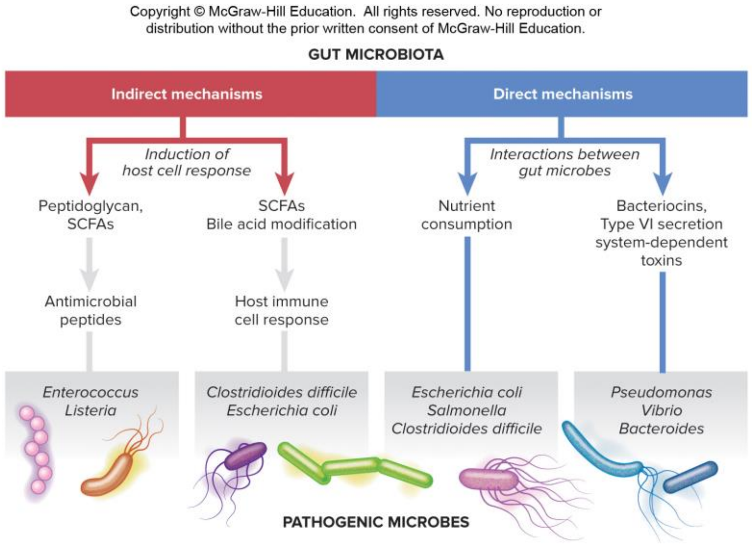
- GF mice can eat more but gain less weight than conventional mice.
- Following fecal microbiome transplant, the formerly GF recipient mice became obese as well, despite no change to their diet or exercise regime.

Immunity

Antibiotics disrupt the gut microbial community.

- Following antibiotics treatment, people are at higher risk of GI tract infections.
- Colonization resistance—based on competitive exclusion.

Microbiome releases toxic peptides that target pathogens.



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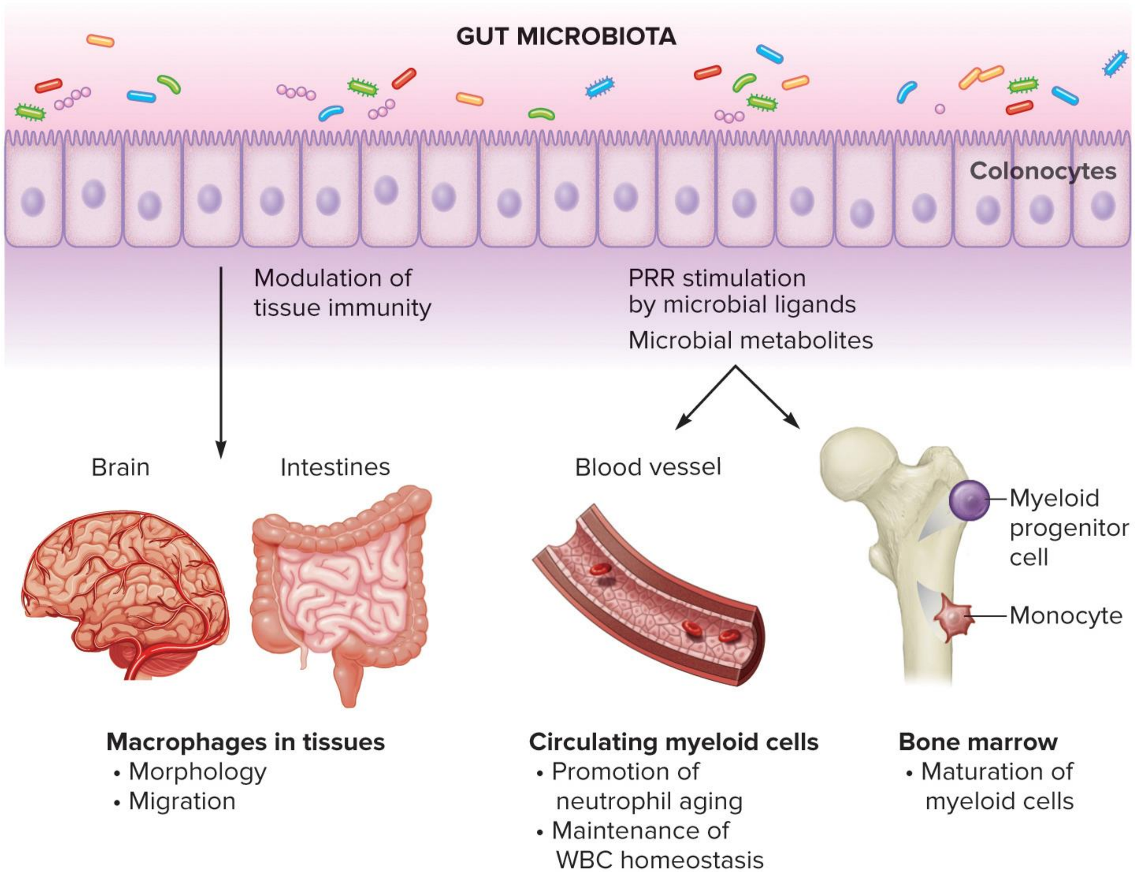
Microbiome Signals Influence Immune Cell Function at Sites Distant from the Gut



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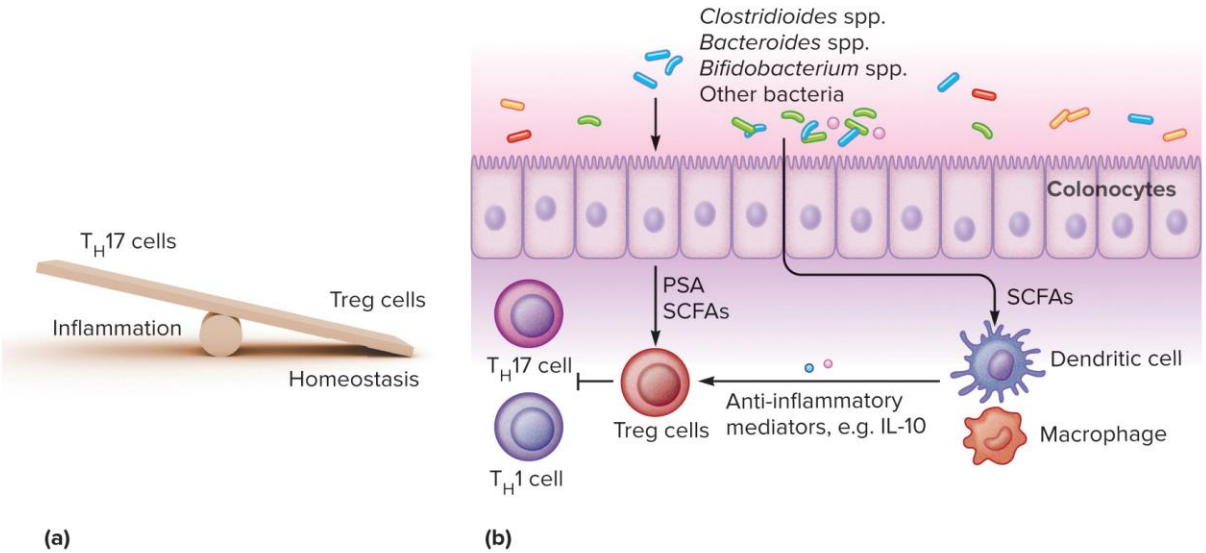
Gut Microbiota Metabolites Regulate Inflammation

Colonocytes and immune cells recognize and respond to microbes in the microbiome in addition to pathogens.



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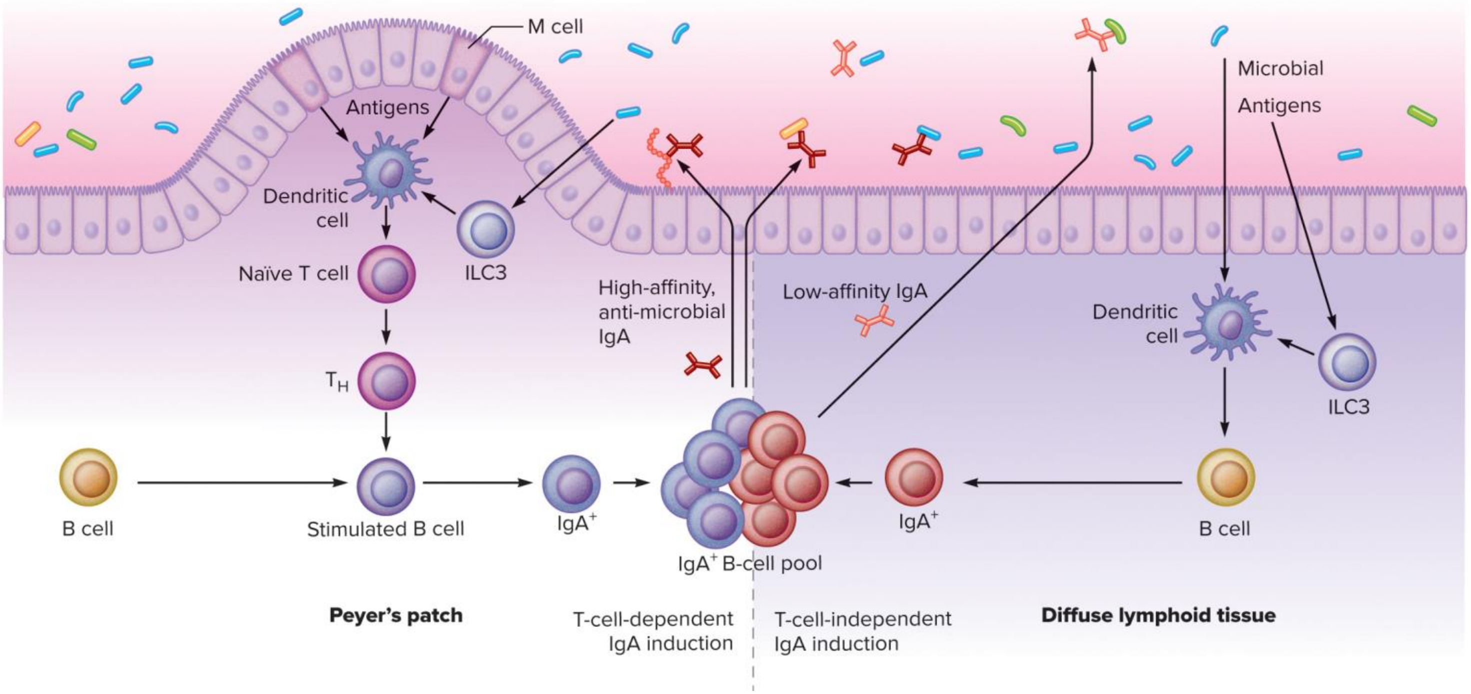
Production of sIgA Requires ILC3 and Microbial Stimulation



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Gut-Brain Axis [1]

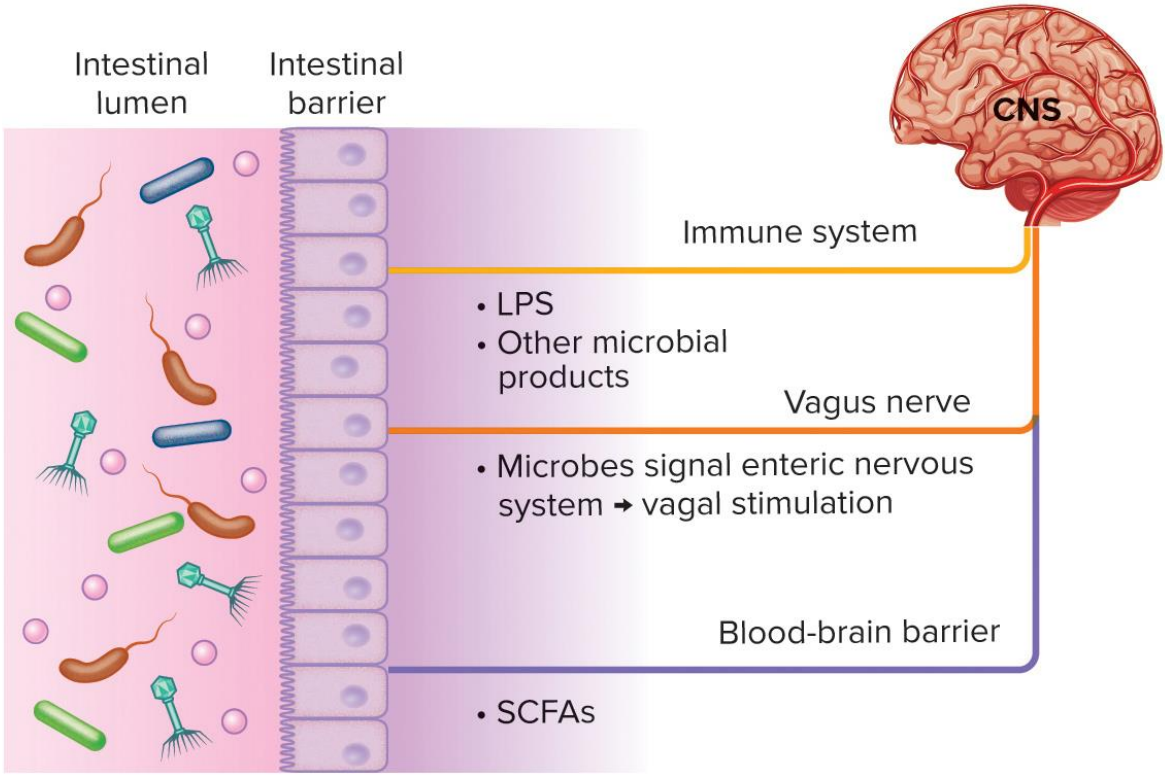
Gut microbiota may affect our central nervous system (CNS).

- Specific behavioral traits (inquisitiveness, sociability, anxiety, depression) differ when comparing GF mice and conventional mice; influence is heritable.

We can predict at least three ways the microbiome can influence the CNS:

- Microbiome effect on the immune system.
- Via enteric nervous system, connected to the CNS by the vagus nerve which transmits signals to the brain.
- Through soluble microbial products like short-chain fatty acids.

Gut-Brain Axis 2



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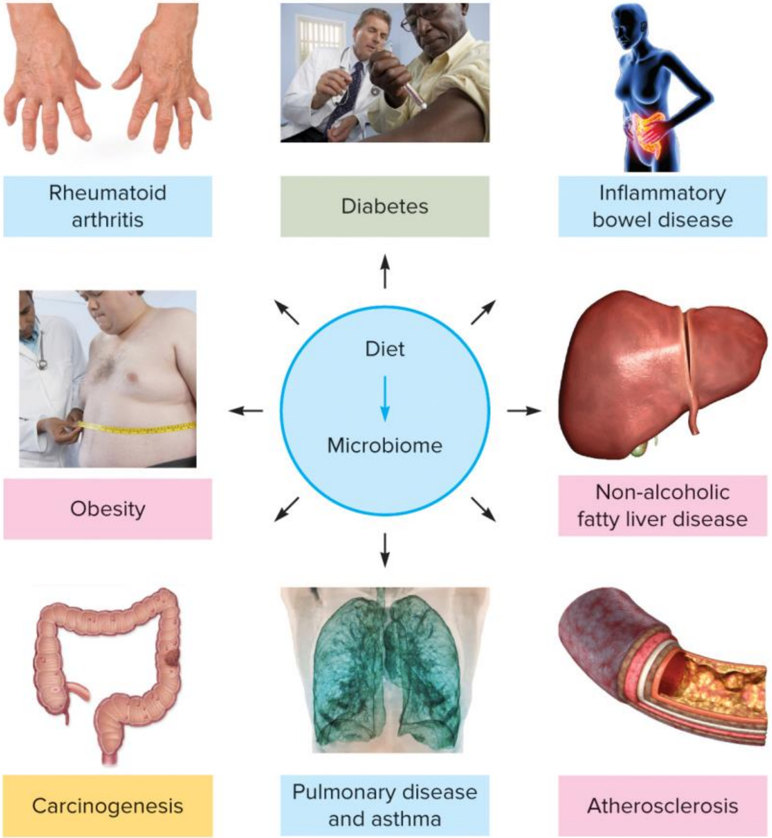
Loss of Microbiome Diversity Leads to Dysbiosis and a Variety of Diseases That Involve Inflammation



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Probiotics

"Live microorganisms, which, when administered in adequate amounts, confer a health benefit to the host" (FAO-WHO).

- U.S. FDA does not regulate probiotic foods and supplements, so claimed health benefits have not been rigorously tested.

Synbiotics—foods or supplements that include both a prebiotic and a probiotic.

- Prebiotic is a compound(s) added to enhance the colonization and positive health benefits of probiotic microbes.