Microbiomics & Aerospace Medicine

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Practical Implications for Flight Crews

Flight crews are directly responsible for the safety of flight operations, and the main challenge for aerospace medicine practitioners is to ensure the medical fitness and performance readiness of generally “normal” individuals who work in “abnormal” aerospace environments

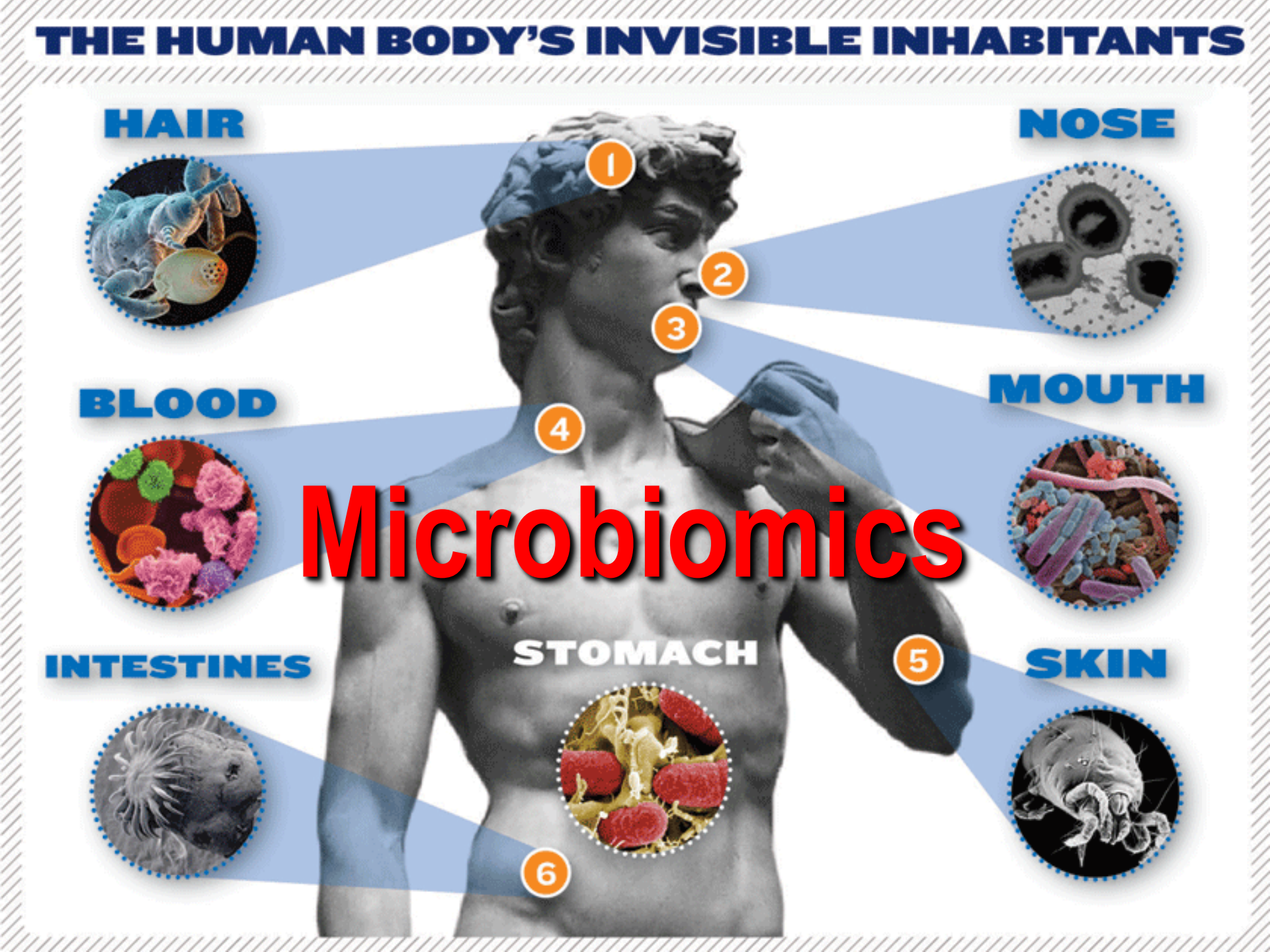
Clinical Aerospace Medicine & Medical Certification/Clearance Issues

- Clinical aerospace medicine issues impacting health monitoring, prevention, screening, diagnosis and treatment

- Most medical personnel around the world are not likely to be very familiar with the field of microbiomics

- Aerospace medical certification/licensing issues (fitness for flight) – Microbiomics can have an impact on the medical clearance of flight crews

THE HUMAN BODY'S INVISIBLE INHABITANTS



The Importance of the MICROBIOME by the Numbers

90%

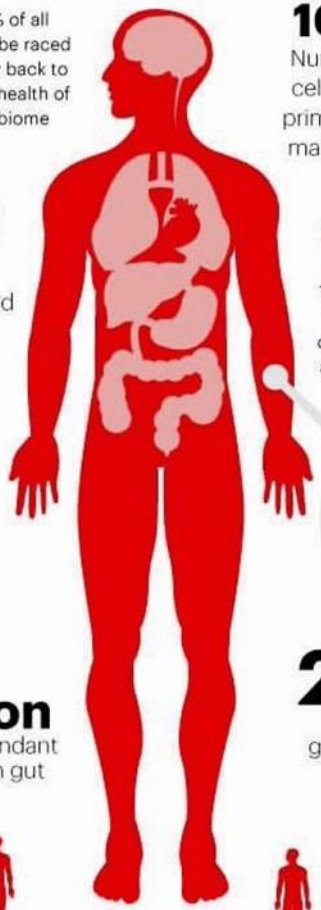
Up to 90% of all disease can be raced in some way back to the gut and health of the microbiome

10–100 trillion

Number of symbiotic microbial cells harbored by each person, primarily bacteria in the gut, that make up the human microbiota

>10,000

Number of different microbe species researchers have identified living in the human body



10X

There are 10 times as many outside organisms as there are human cells in the human body

100 to 1

The genes in our microbiome outnumber the genes in our genome by about 100 to 1

3.3 million

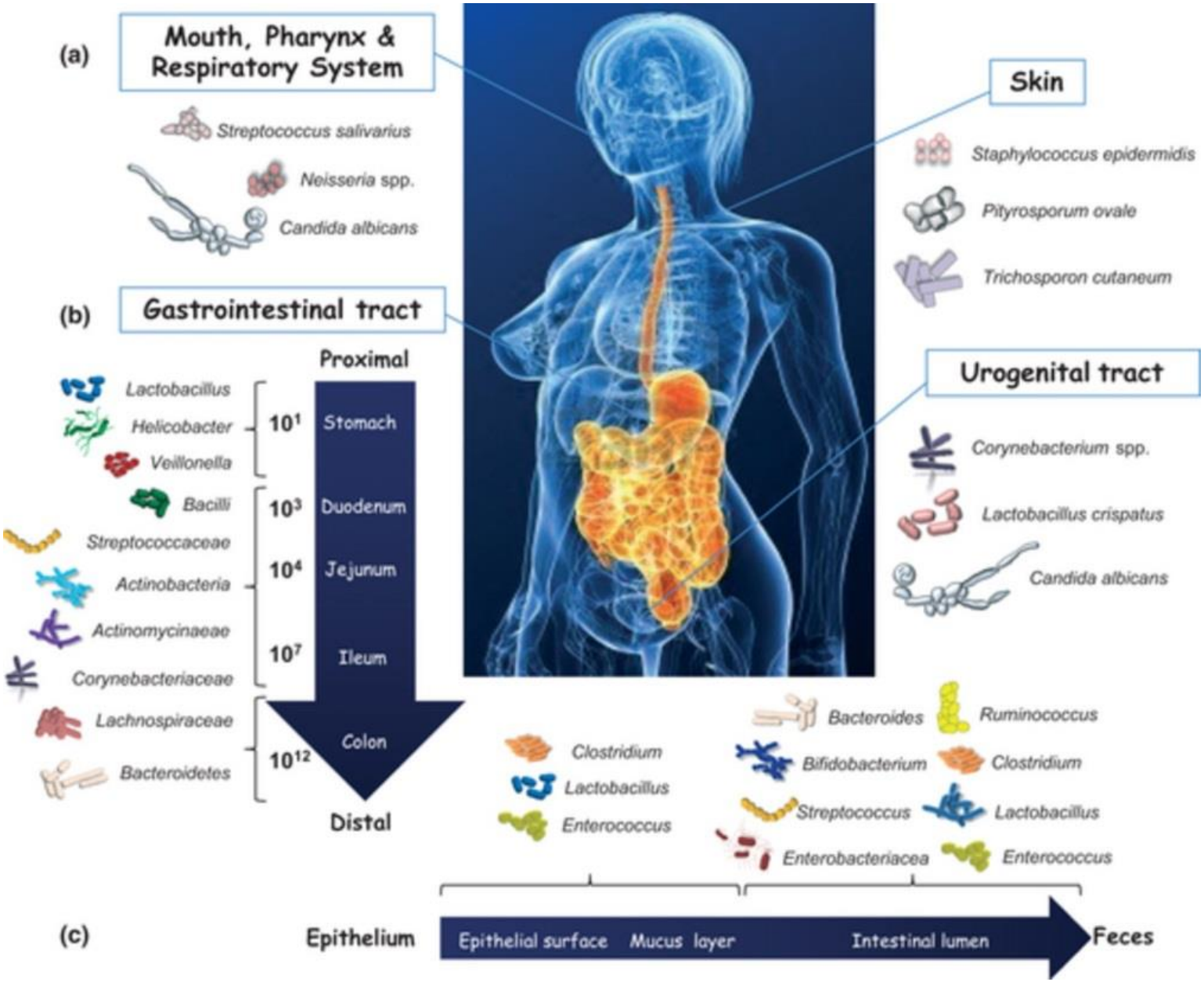
Number of non-redundant genes in the human gut microbiome

22,000

Approximate number genes in the human gene catalog

Percentage individual humans are identical to one another in terms of host genome

Percentage individual humans are different from one another in terms of the microbiome


(a)
Mouth, Pharynx & Respiratory System
Streptococcus salivarius
Neisseria spp.
Candida albicans
Skin
Staphylococcus epidermidis
Pityrosporum ovale
Trichosporon cutaneum
(b)
Gastrointestinal tract
Proximal
Lactobacillus
Helicobacter
Veillonella
10^1
Stomach
Bacilli
10^3
Duodenum
Streptococcaceae
10^4
Jejunum
Actinobacteria
Actinomycinaeae
10^7
Ileum
Corynebacteriaceae
Lachnospiraceae
Colon
10^{12}
Bacteroidetes
Distal
Urogenital tract
Corynebacterium spp.
Lactobacillus crispatus
Candida albicans
Clostridium
Lactobacillus
Enterococcus
Bacteroides
Bifidobacterium
Streptococcus
Enterobacteriacea
Ruminococcus
Clostridium
Lactobacillus
Enterococcus
(c)
Epithelium
Epithelial surface
Mucus layer
Intestinal lumen
Feces

THE HUMAN MICROBIOME

Bacteria, fungi, and viruses outnumber human cells in the body by a factor of 10 to one. The microbes synthesize key nutrients, fend off pathogens and impact everything from weight gain to perhaps even brain development. The Human Microbiome Project is doing a census of the microbes and sequencing the genomes of many. The total body count is not in but it's believed over 1,000 different species live in and on the body.

600+ SPECIES

in the mouth, pharynx and respiratory system include:

- Streptococcus viridans
- Neisseria sicca
- Candida albicans
- Streptococcus salivarius

25 SPECIES

in the stomach include:

- Helicobacter pylori
- Streptococcus thermophilus

1,000 SPECIES

in the skin include:

- Pityrosporum ovale
- Staphylococcus epidermidis
- Corynebacterium jeikeium
- Trichosporon
- Staphylococcus haemolyticus

500–1,000 SPECIES

in the intestines include:

- Lactobacillus casei
- Lactobacillus reuteri
- Lactobacillus gasseri
- Escherichia coli
- Bacteroides fragilis
- Bacteroides thetaiotaomicron

60 SPECIES

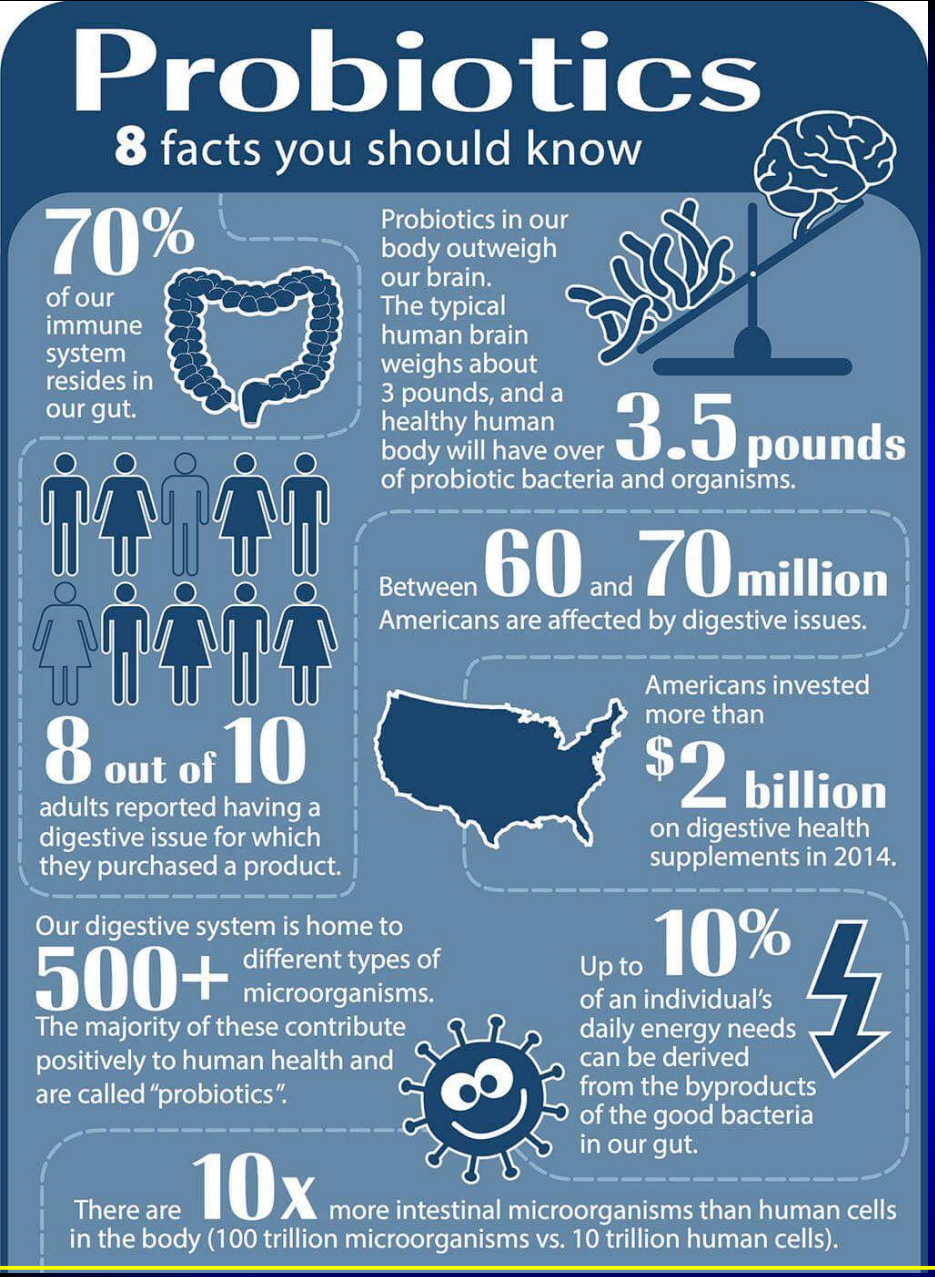
in the urogenital tract include:

- Ureaplasma parvum

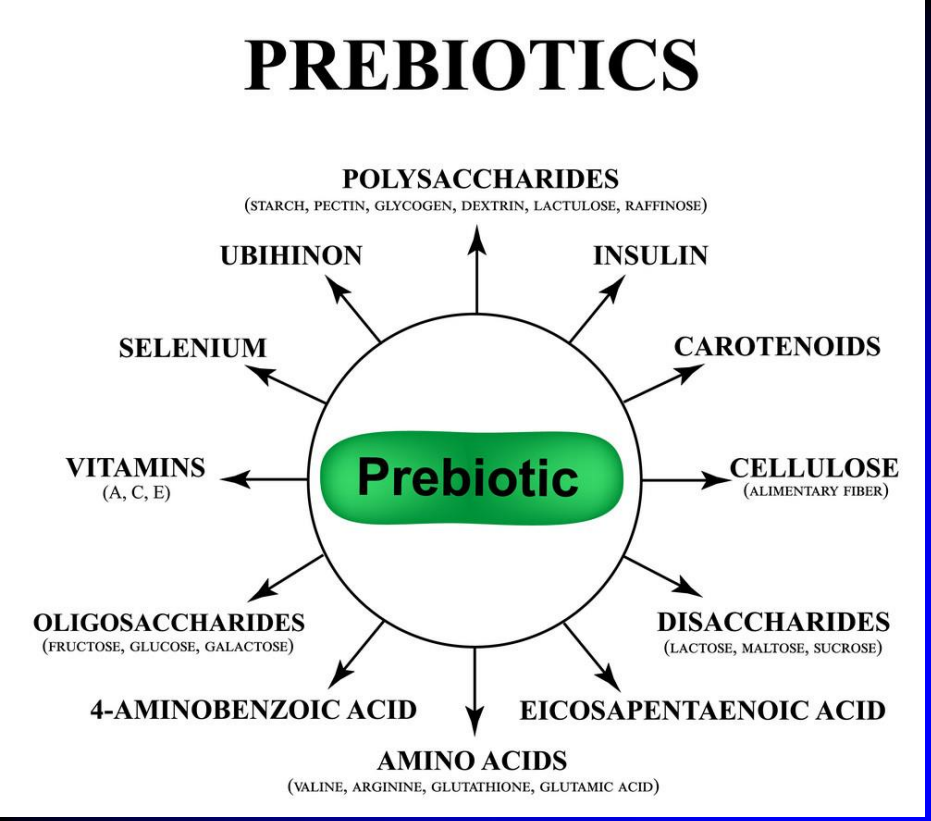
- The composition and functional impact of the microbiome in the human body jointly develops from birth and is affected by the person's nutrition, genetic composition, general lifestyle, self-imposed stress and exposure to environmental stress factors
- The interaction of the GI microbiome with human cells influences the regulation of some metabolic pathways and immune-inflammatory pathways impacting the intestines, liver, muscle, and brain
- A decrease in the desirable GI microbiome can lead to deterioration in GI, endocrine, neurologic or immune functions, and could lead to diseases

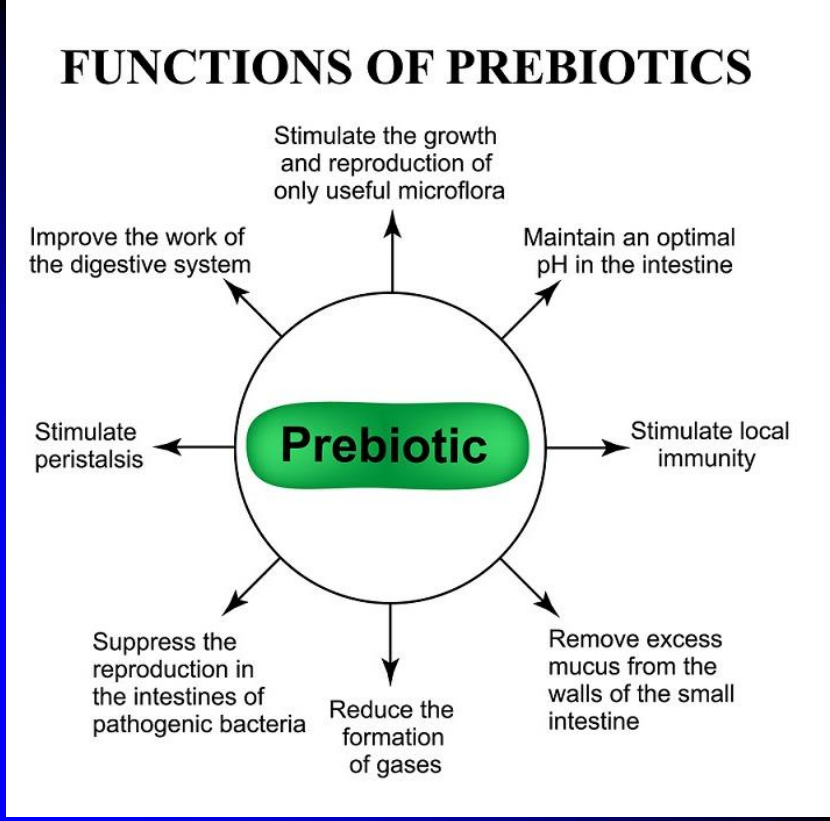
Nutrition/Diet

- Probiotics/Prebiotics
- Pre/Probiotics and Improved Immune Function
- Probiotics vs Antibiotics
- Antibiotics and Microbiome
- Food-Borne Pathogens
- Role of pre/probiotics against foodborne pathogens
- Bacteria and Dietary-Derived Metabolites
- Role of Plant/Soil Microbiome
- Microbiome-Directed Foods

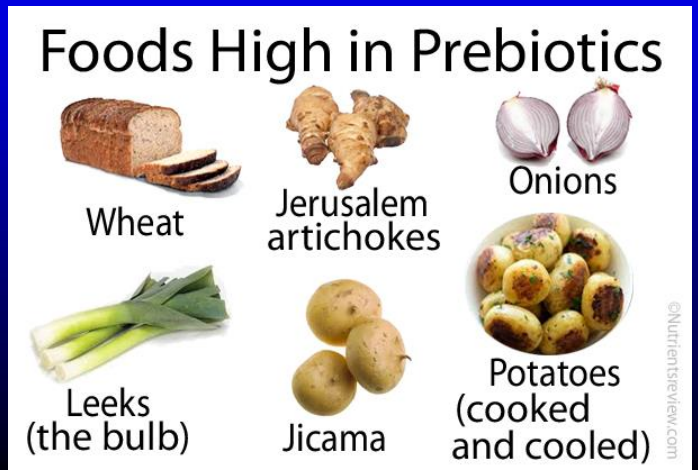


Probiotics are types of living friendly bacteria similar to those that inhabit the GI tract used to adjust the microbiome to protect the individual



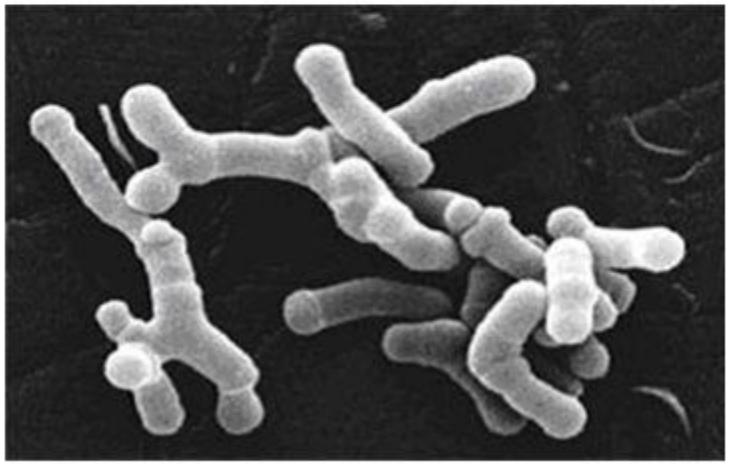


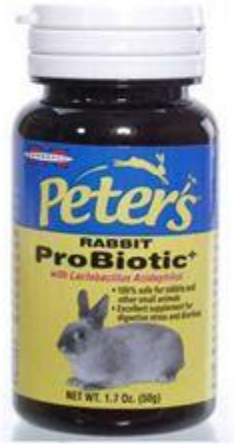
Prebiotics are nutrients that 'feed' the good bacteria

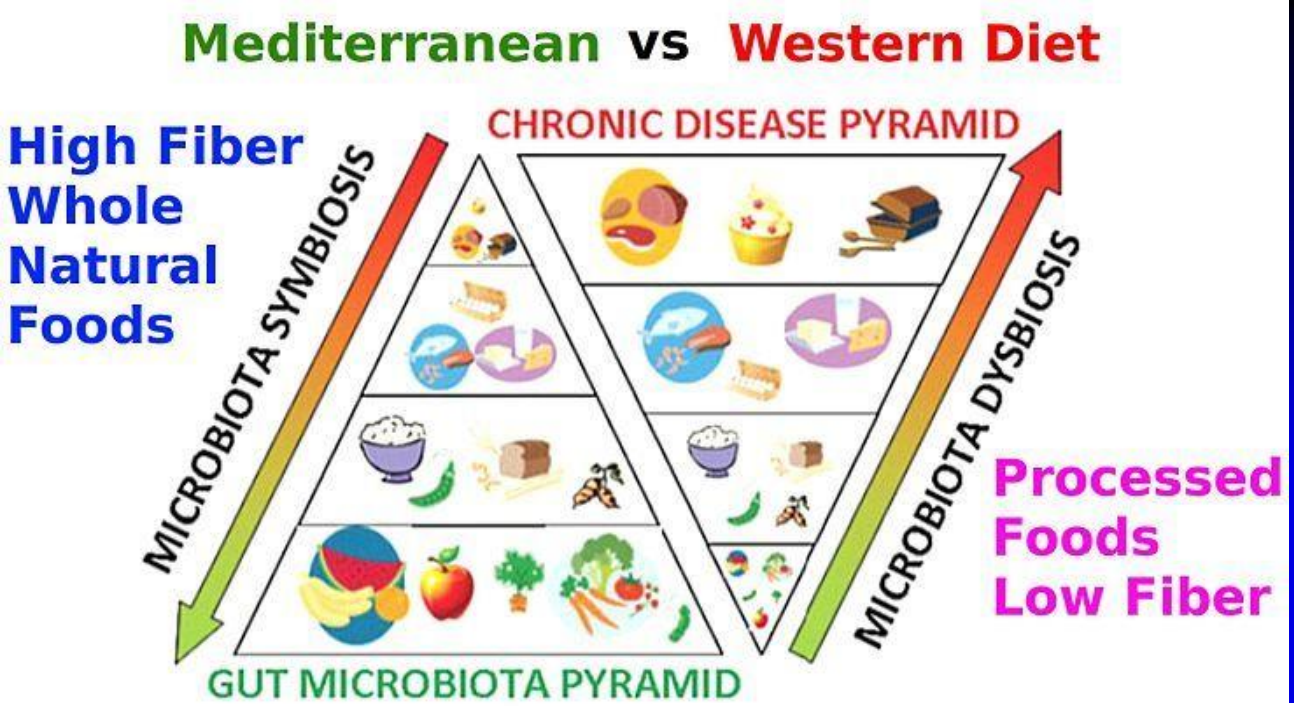


Probiotics vs antibiotics

- Antibiotics
  - damage commensal microflora.
  - can increase the occurrence of resistant bacteria
  - can have adverse side effects
- Probiotics
  - can be used in adjunction to antibiotics to restore the commensal microflora

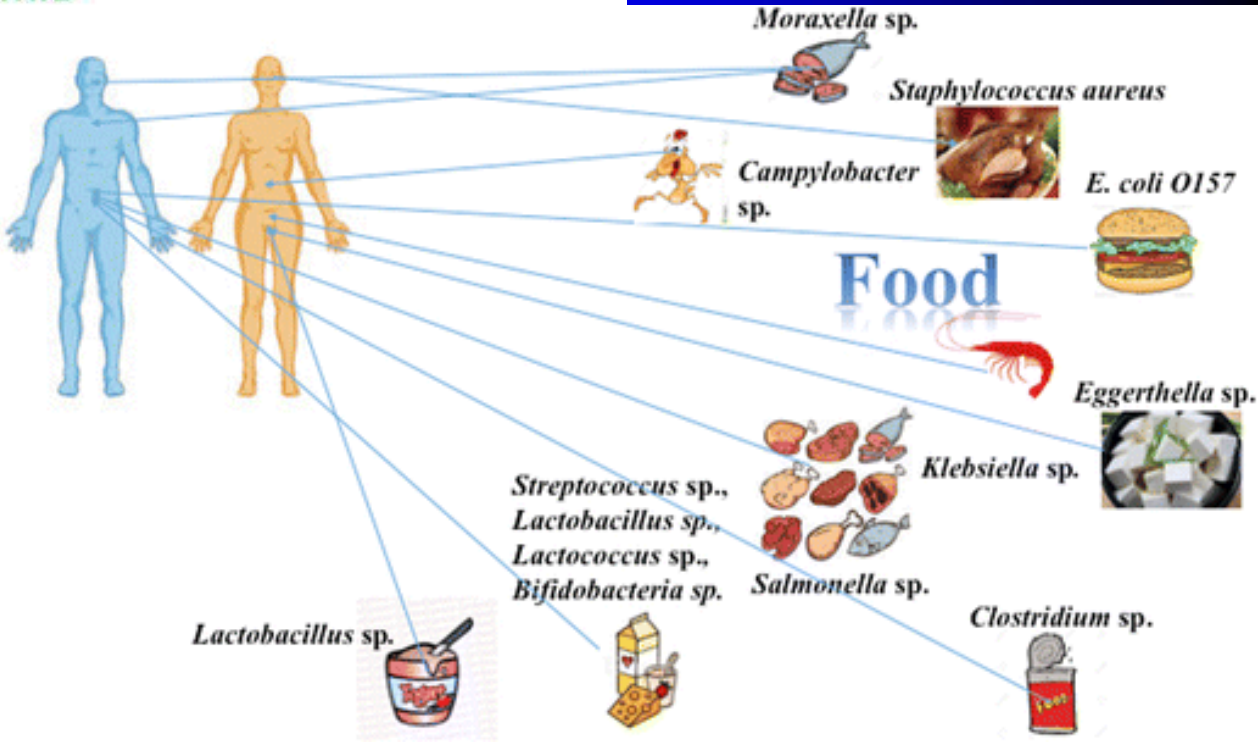






Foodborne Pathogens

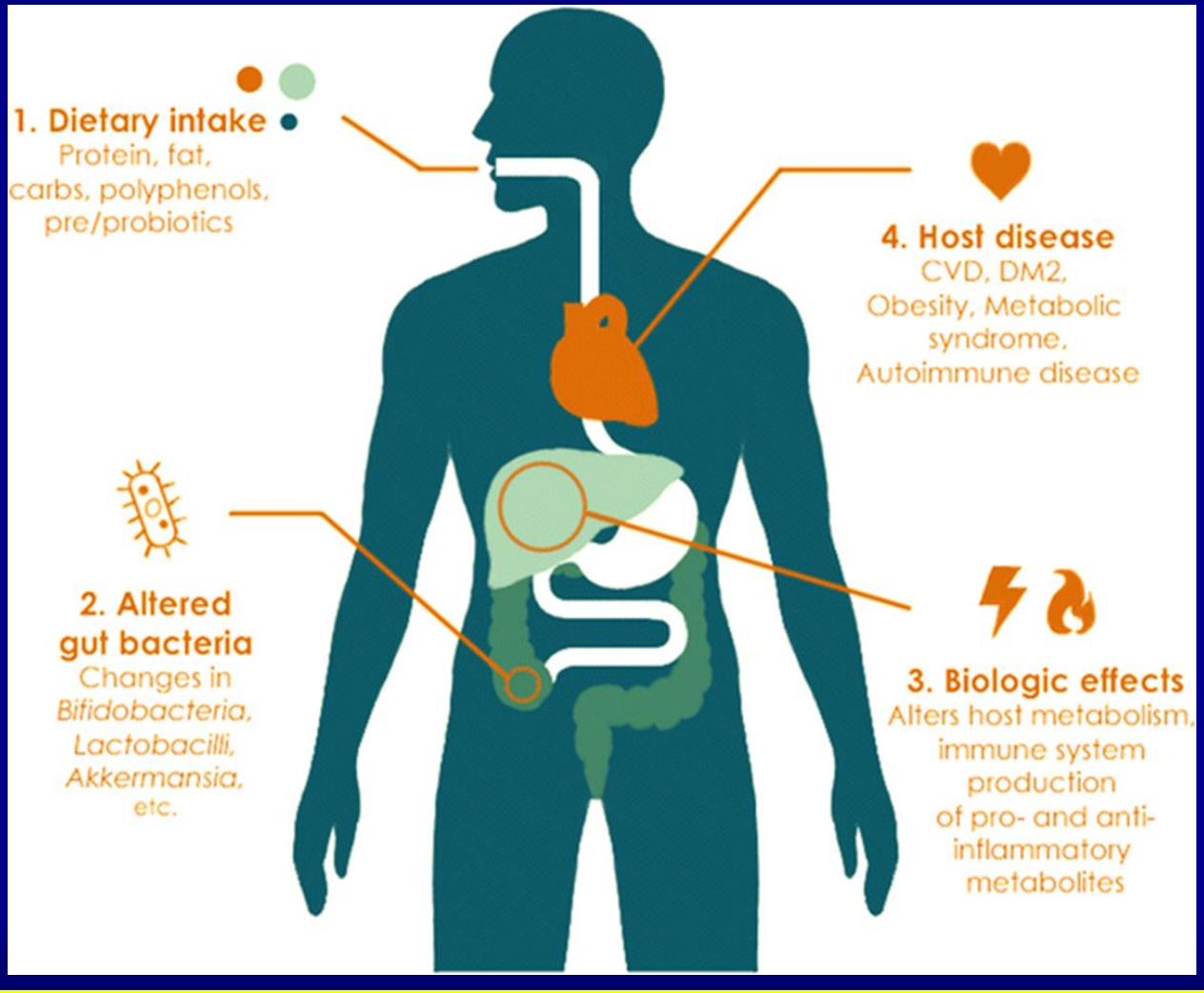
Probiotics Reduce Foodborne Pathogens



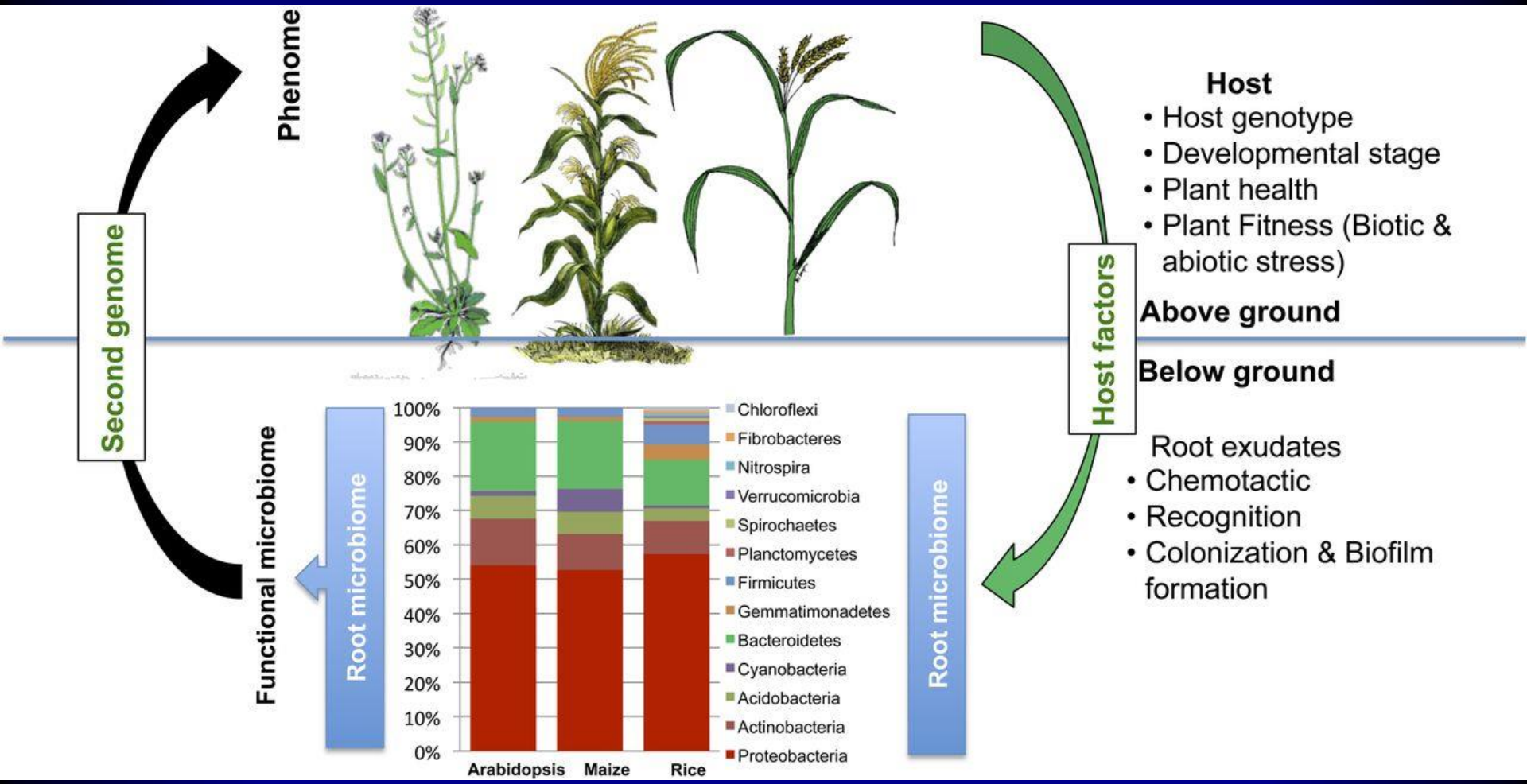
ASSESSING THE ANTIBACTERIAL PROPERTIES OF PROBIOTICS AGAINST FOOD BORNE PATHOGENS

BY: SANEEA IMRAN | SUPERVISOR: DR. RUMEZA HANIF

Bacteria and Dietary-Derived Metabolites

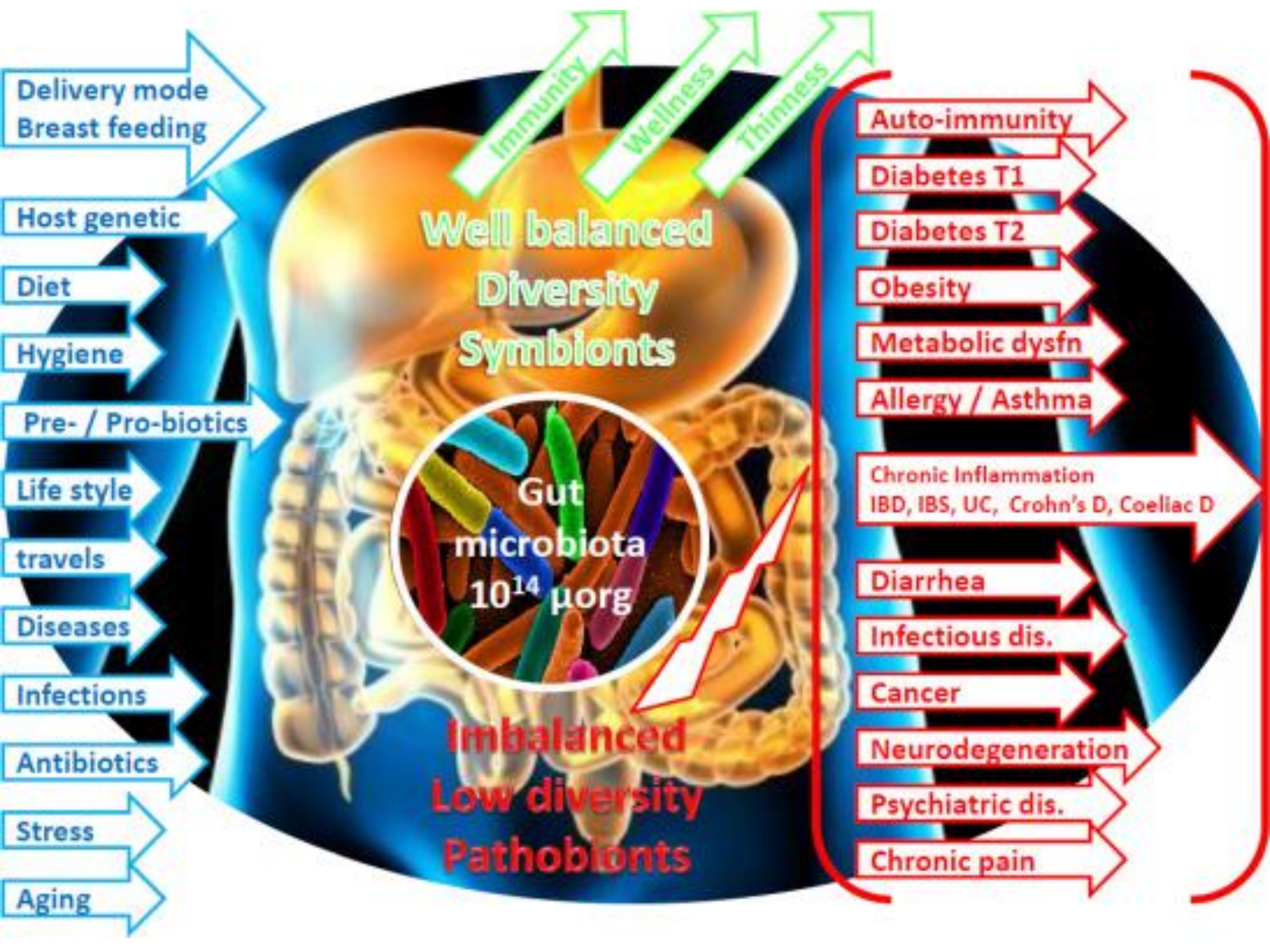


Plant & Soil Microbiome – Impact on the Human Microbiome



Diseases

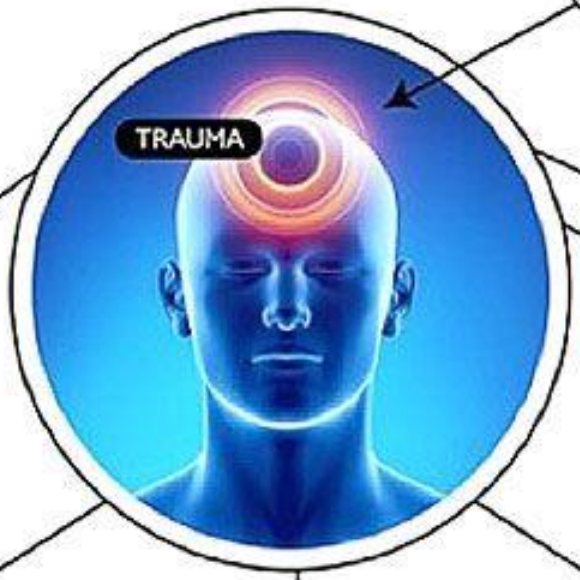
- Inhibition of Disease Vectors
- Traveler's Diarrhea
- Respiratory Infections
- Asthma
- Drug Metabolism
- Multidrug Resistance
- Impaired Immunity
- Irritable Vowel Syndrome
- Inflammatory Bowel Disease
- Multiple Sclerosis
- Acute Mountain Sickness


Delivery mode
Breast feeding
Host genetic
Diet
Hygiene
Pre- / Pro-biotics
Life style
travels
Diseases
Infections
Antibiotics
Stress
Aging
Immunity
Wellness
Thinness
Well balanced
Diversity
Symbionts
Gut
microbiota
10^14 µorg
Imbalanced
Low diversity
Pathobionts
Auto-immunity
Diabetes T1
Diabetes T2
Obesity
Metabolic dysfn
Allergy / Asthma
Chronic Inflammation
IBD, IBS, UC, Crohn's D, Coeliac D
Diarrhea
Infectious dis.
Cancer
Neurodegeneration
Psychiatric dis.
Chronic pain

Injury

- Traumatic Brain Injury – Gut/Brain/Axis
- Blast Injury – Infection – Gut Microbiome
- Wound Infections – Skin Microbiome
- Wound Healing – Skin Microbiome

TRAUMATIC BRAIN INJURY MECHANISMS OF GASTROINTESTINAL TRACT



NEUROINFLAMMATION

BREAKDOWN OF BLOOD-BRAIN BARRIER

CORTICO-PONTINE DYSREGULATION

DISRUPTION OF BRAINSTEM INTEGRATION

DYSAUTONOMIA

ALTERED HEART RATE
ALTERED VISCERAL BLOOD FLOW
ALTERED DIGESTIVE ENZYME RELEASE

LOSS OF BRAIN INTEGRATION

BRAIN-IMMUNE IMPAIRMENT

IMMUNE SUPPRESSION
IMMUNE DYSREGULATION

DISRUPTED INSULAR CORTEX
HYPOTHALAMUS
CORTICO-PONTINE

ALTERED INTEROCEPTIVE PROCESSING

IMPAIRED VALVE CONTROL
IMPAIRED MOTILITY
IMPAIRED PROPRIOCEPTION

IMPAIRED VAGAL MOTOR ACTIVITY

REDUCED INTESTINAL CONTRACTIBILITY

IMPAIRED MOTILITY
BACTERIA TRANSLOCATION
IMPAIRED DEFECATION
IMPAIRED VALVE CONTROL

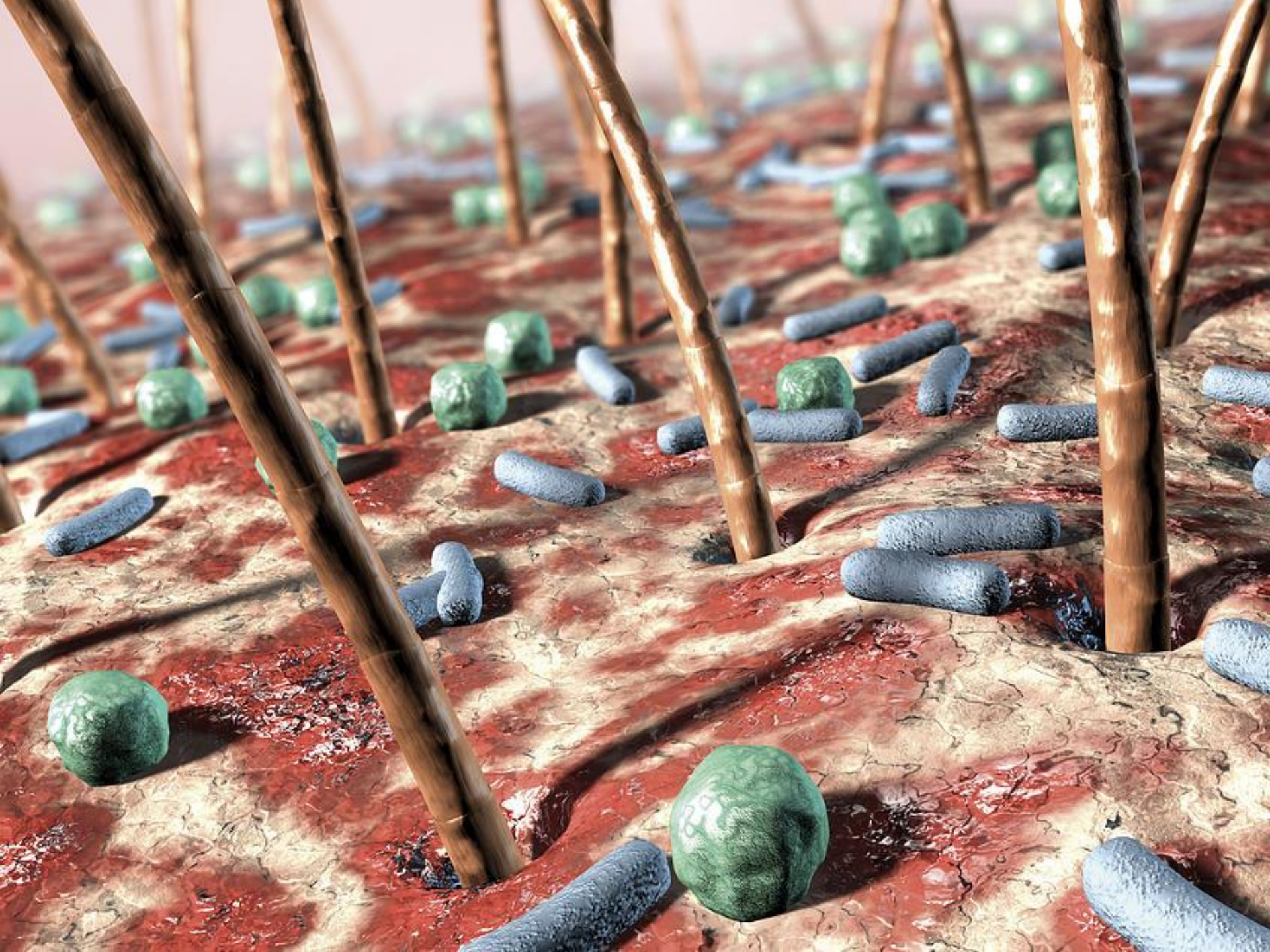
DISRUPTION OF CORTICO-PONTINE INTEGRATION

INTESTINAL PERMEABILITY

INTESTINAL MUCOSA COMPROMISE

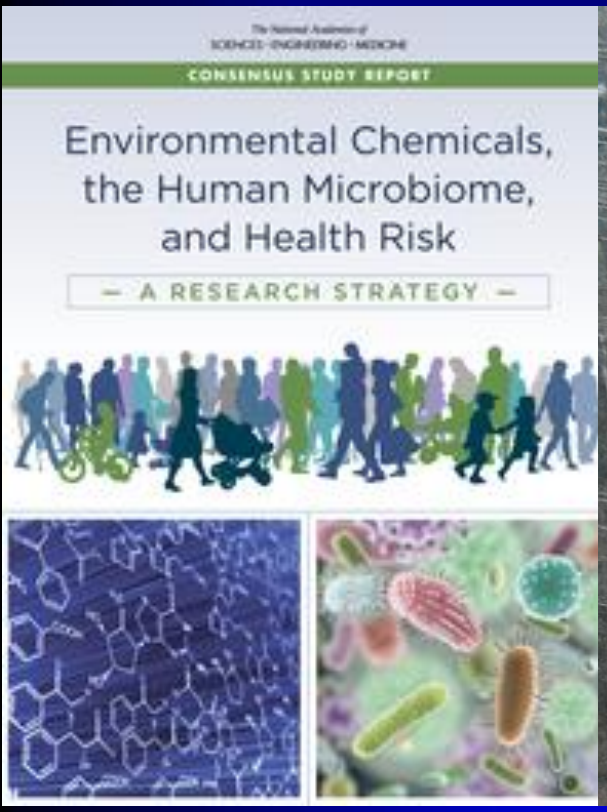
INTESTINAL INFLAMMATION
PROTEIN PERMEABILITY
MALABSORPTION

GASTROINTESTINAL DYSFUNCTION



Environmental Exposure

- Chemicals
- Heavy Metals
- Hypoxia
- Hypobaria
- Microgravity


CONSENSUS STUDY REPORT
Environmental Chemicals, the Human Microbiome, and Health Risk
— A RESEARCH STRATEGY —


Arsenic
Tungsten
Nickel
Beryllium
Antimony
Platinum
Cadmium
Cesium
Aluminum
Lead
Barium
Tin
Copper
Uranium
Thorium
Mercury
Thallium
HEAVY METALS

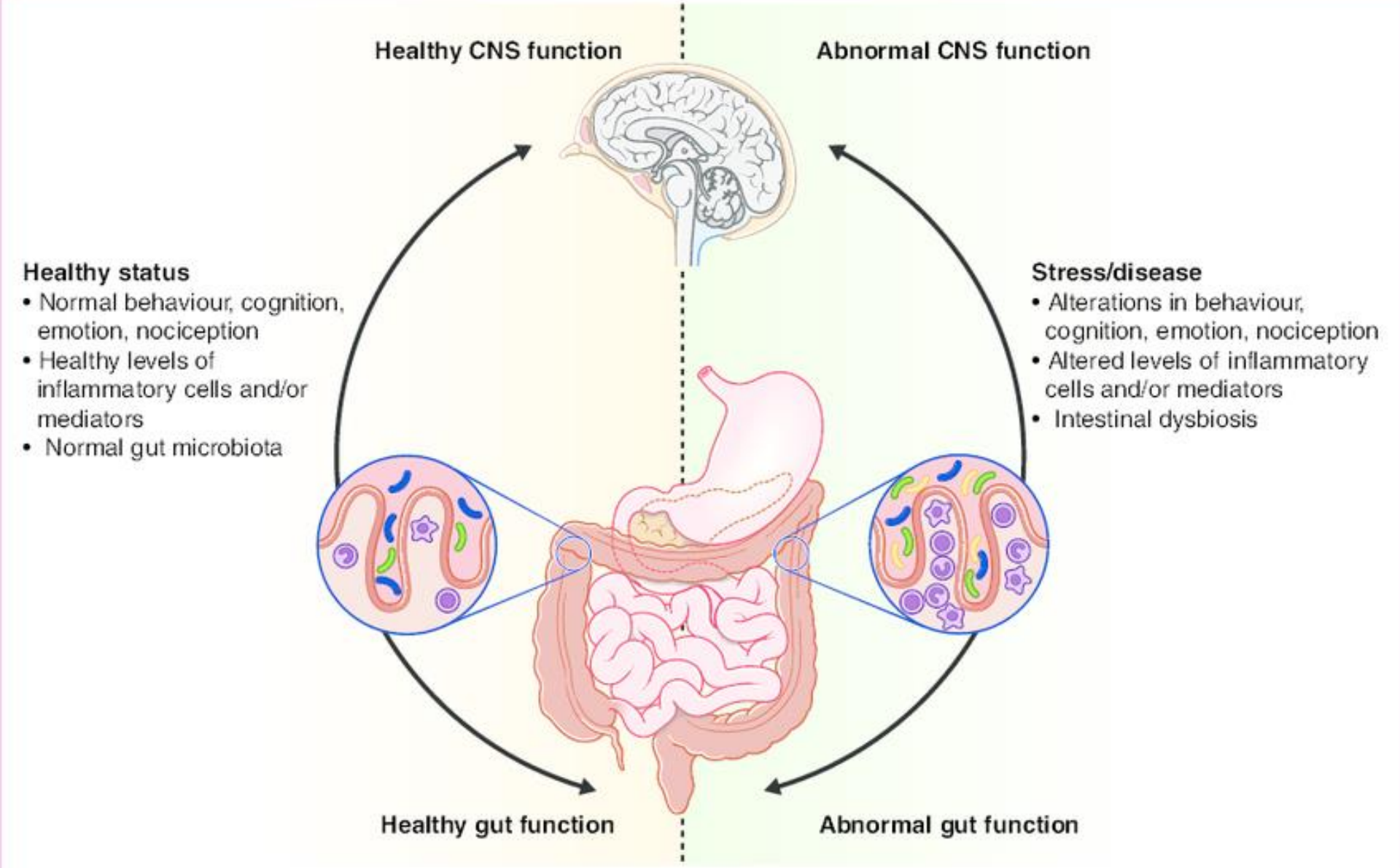
- The microbiome plays an important role in regulating many physiological and pathological processes in the human body

- NASA is currently sponsoring the “Study of the Impact of Long-Term Space Travel on the Astronaut’s Microbiome. The goal of this study is to determine how the composition of the human microbiome is altered during long-term space exploration and to evaluate its potential impact on space crew health

NASA Twins Study

Neurological Issues

- Activation/Inhibition of Neuronal Activity
- Stress & Performance
- Cognition
- Anxiety/Fear
- Sleep/Circadian Rhythm Disruption
- Neurochemical/Neurotransmitter
- Microbiome Gut-Brain Axis/Circuits


Healthy CNS function
Abnormal CNS function
Healthy status
• Normal behaviour, cognition, emotion, nociception
• Healthy levels of inflammatory cells and/or mediators
• Normal gut microbiota
Stress/disease
• Alterations in behaviour, cognition, emotion, nociception
• Altered levels of inflammatory cells and/or mediators
• Intestinal dysbiosis
Healthy gut function
Abnormal gut function

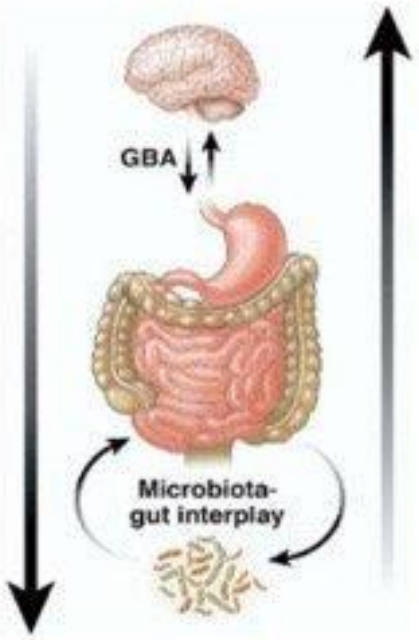
The Bidirectional Gut-Brain Axis

The ability of the brain to influence the intestinal microbiota

Perturbation of your normal habitat via stress-induced changes in gastrointestinal:

- Physiology
- Epithelial function
- Mucin production
- EE cell function
- Motility

Release of Neurotransmitters



The ability of the microbiota to influence brain, behavior, and mood

Activation of neural pathways to the brain

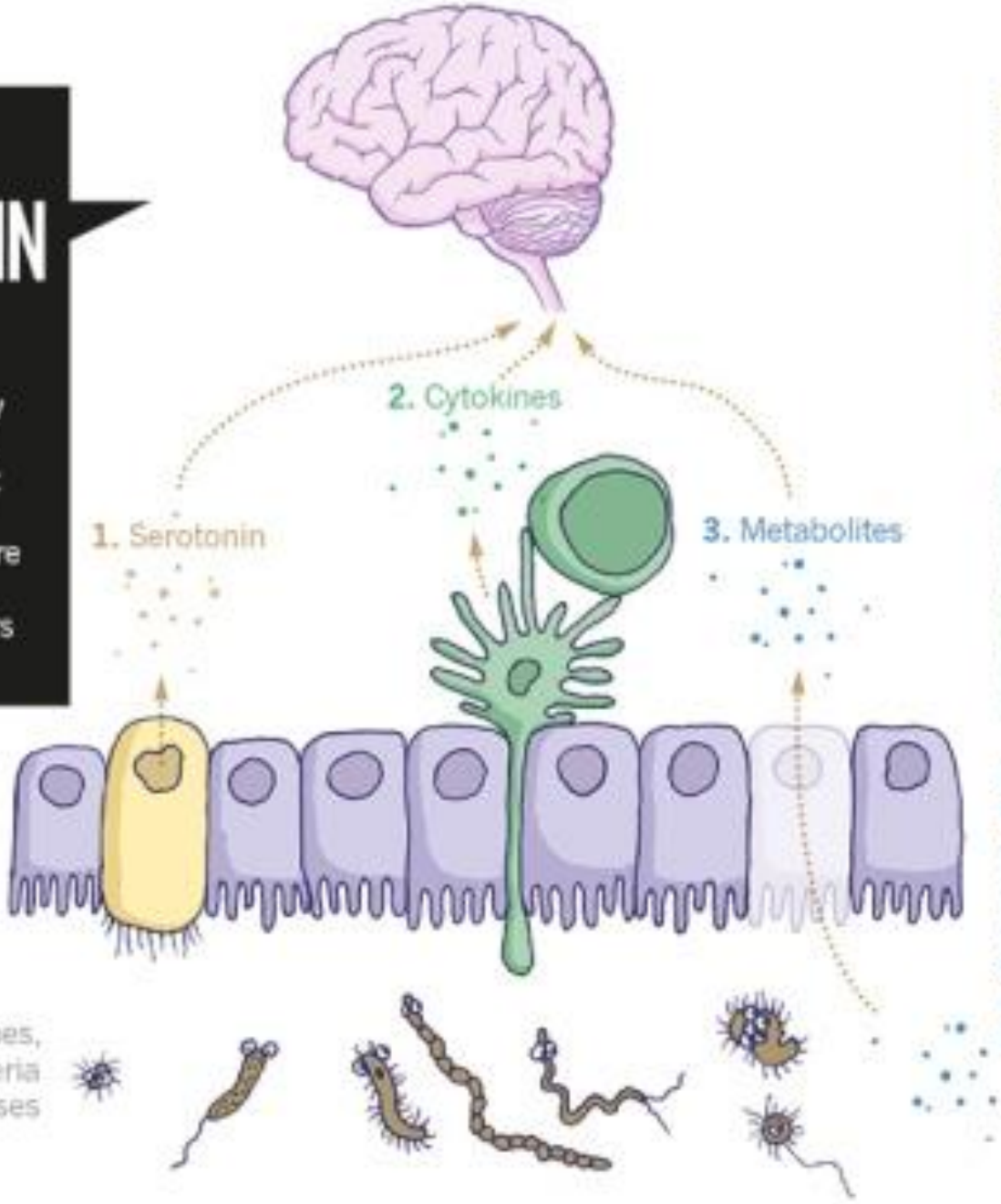
Activation of musosal immune responses

Production of metabolites that directly affect the CNS

Grenham S, Clarke G, Cryan JF, Dinan TG. Brain-gut-microbe communication in health and disease. Front Physiol. 2011;2:94. Epub 2011 Dec 7. PubMed PMID: 22162969; PubMed Central PMCID: PMC3232439

THE GUT–BRAIN AXIS

The mechanisms by which gut microbes and the brain might communicate are unclear, but there are several tantalizing leads for researchers to follow.



1. PERIPHERAL SEROTONIN: Cells in the gut produce large quantities of the neurotransmitter serotonin, which may have an effect on signalling in the brain.

2. IMMUNE SYSTEM: The intestinal microbiome can prompt immune cells to produce cytokines that can influence neurophysiology.

3. BACTERIAL MOLECULES: Microbes produce metabolites such as butyrate, which can alter the activity of cells in the blood–brain barrier.

Other Issues

- Microbiome Biosensors for Health/Disease
- Microbiome Forensic Identity Marker
- Dietary Effects at Low/High Elevation/Altitude on the Microbiome
- Chemotherapy effects on microbiome
- Lung microbiome and health risks of particulate matter/emissions (smoke)
- Effects of indoor microbiomes in enclosed environments on humans