Microbiomics & Aerospace Medicine

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By: Melchor J. Antuñano, M.D., M.S.
    Director, Civil Aerospace Medical Institute
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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

Microbiomics & Aerospace Medicine
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

Microbiomics

- Hair
- Nose
- Blood
- Mouth
- Intestines
- Stomach
- Skin

Microbiomics
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
- **>10,000** Number of different microbe species researchers have identified living 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
- **10-100 trillion** Number of symbiotic microbial cells harbored by each person, primarily bacteria in the gut, that make up the human microbiota
- **10X** There are 10 times as many outside organisms as there are human cells in the human body
- **22,000** Approximate number of genes in the human gene catalog
- **99.9%** Percentage individual humans are identical to one another in terms of host genome
- **80%–90%** Percentage individual humans are different from one another in terms of the microbiome
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.

25 SPECIES in the stomach include:
- Helicobacter pylori
- Streptococcus thermophilus

500-1,000 SPECIES in the intestines include:
- Lactobacillus casei
- Lactobacillus reuteri
- Lactobacillus gasseri
- Escherichia coli
- Bacteroides fragilis
- Bacteroides thetaiotaomicron
- Lactobacillus brevis

600+ SPECIES in the mouth, pharynx and respiratory system include:
- Streptococcus viridans
- Neisseria sicca
- Candida albicans
- Streptococcus salivarius

1,000 SPECIES in the skin include:
- Pityrosporum ovale
- Staphylococcus epidermidis
- Corynebacterium jeikeium
- Trichosporon
- Staphylococcus haemolyticus

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

**Foods High in Prebiotics**
- Wheat
- Jerusalem artichokes
- Onions
- Leeks (the bulb)
- Jicama
- Potatoes (cooked and cooled)
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

High Fiber Whole Natural Foods

Mediterranean vs Western Diet

CHRONIC DISEASE PYRAMID

GUT MICROBIOTA PYRAMID

MICROBIOTA Symbiosis

MICROBIOTA DYSBIOSIS

Processed Foods Low Fiber

Moraxella sp.

Staphylococcus aureus

Campylobacter sp.

E. coli O157

Eggerthella sp.

Streptococcus sp., Lactobacillus sp., Lactococcus sp., Bifidobacteria sp.

Salmonella sp.

Clostridium sp.

Lactobacillus sp.
ASSESSING THE ANTIBACTERIAL PROPERTIES OF PROBIOTICS AGAINST FOOD BORNE PATHOGENS

BY: SANEEA IMRAN | SUPERVISOR: DR. RUMEZA HANIF
Bacteria and Dietary-Derived Metabolites

1. Dietary intake
   - Protein, fat, carbs, polyphenols, pre/probiotics

2. Altered gut bacteria
   - Changes in *Bifidobacteria*, *Lactobacilli*, *Akkermansia*, etc.

3. Biologic effects
   - Alters host metabolism, immune system production of pro- and anti-inflammatory metabolites

4. Host disease
   - CVD, DM2, Obesity, Metabolic syndrome, Autoimmune disease
Plant & Soil Microbiome – Impact on the Human Microbiome

Host factors
- Host genotype
- Developmental stage
- Plant health
- Plant Fitness (Biotic & abiotic stress)

Above ground
- Root exudates
- Chemotactic
- Recognition
- Colonization & Biofilm formation

Below ground

Host

Functional microbiome

Phenome

Second genome

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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
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
- Disrupted insular cortex hypothalamus cortico-pontine
  - Altered interoceptive processing
    - Impaired valve control
    - Impaired motility
    - Impaired proprioception

Impaired vagal motor activity
- Reduced intestinal contractility
- 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
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.
Neurological Issues

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

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.

Gut microbes, including bacteria and viruses
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