



# **Microbiological Risk**

**Lessons Learned and Best Practices  
for a Living, Adapting Contaminant**

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# Adverse Effects of Microorganisms

## Infectious disease

Urinary tract infection

Gastroenteritis

Viral reactivation

Dental abscess

Upper respiratory infection

Skin/wound infections

Immune responses

- Allergic rhinitis

- Hypersensitivity

- Biodegradation
- Toxin production
- Systems failure
- Food spoilage
- Release of volatiles
- Plant disease



# Spaceflight and Infectious Disease Risk

- **Negative factors**
  - Small enclosed environment
  - Recycled air/water
  - Limited diagnostics and treatment on board
  - Remote location with limited return options
  - Stressful conditions
- **Positive factors**
  - Healthy, well-conditioned crew
  - Preflight medical exams
  - Limited exposure to many public health pathogens
  - Medical consult throughout a mission
  - Stringent microbiological monitoring

# Health Stabilization Program

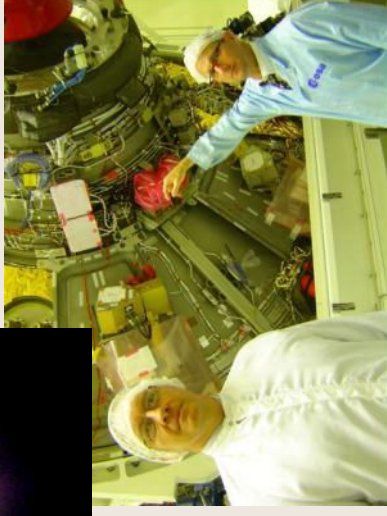
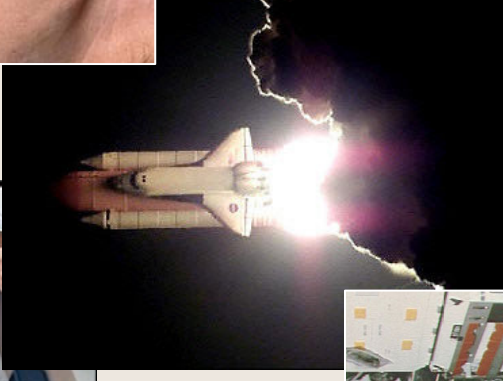


| <u>Mission</u> | <u>Illness (Crew)</u>           |
|----------------|---------------------------------|
| Apollo 7       | Upper respiratory infection (3) |
| Apollo 8       | Viral gastroenteritis (3)       |
| Apollo 9       | Upper respiratory infection (3) |
| Apollo 10      | Upper respiratory infection (2) |
| Apollo 11      |                                 |
| Apollo 12      | Skin infection (2)              |
| Apollo 13      | Rubella (1)                     |
| Apollo 14      |                                 |
| Apollo 15      |                                 |
| Apollo 16      |                                 |
| Apollo 17      | Skin infection (1)              |
| Skylab-2       |                                 |
| Skylab-3       | Skin infection (2)              |
| Skylab-4       | Skin infection (2)              |

*Ref: Billica, Pool, Nicogossian, 1994*

# Preflight Microbiological Monitoring

- Crewmembers
- Food
- Potable water
- Vehicle surfaces
- Vehicle air
- Cargo
- Biosafety review of payloads



# Monitoring - Acceptability Limits

## *Food Acceptability Limits*

- Total aerobic count <20,000 CFU\*/gram
- *Escherichia coli* <1 CFU/gram
- Coagulase positive Staphylococci <1 CFU/gram
- *Salmonella* <1 CFU/gram
- Yeast and Molds <1000 CFU/gram

[CFU\* = Colony Forming Units]



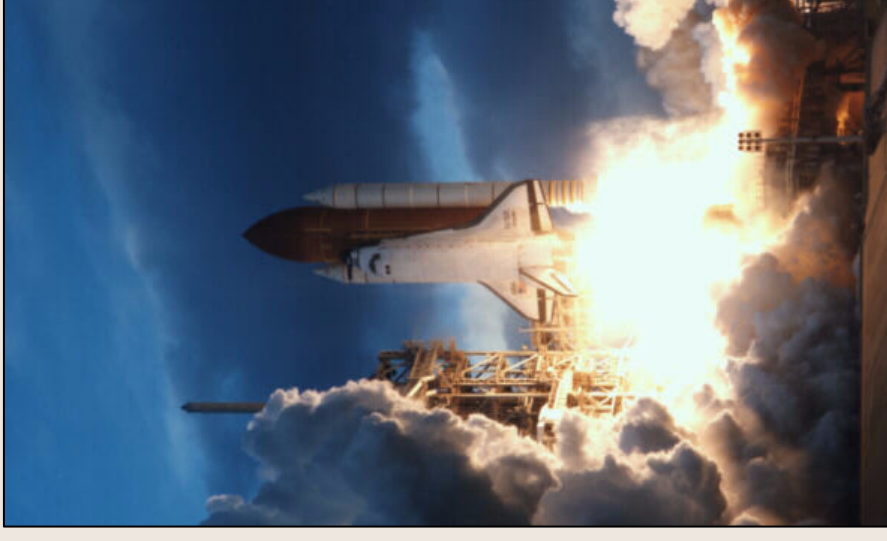
## **Awareness:**

A sample of chicken salad was identified with 16,000 CFU/ gram of the organism, *Pseudomonas aeruginosa*, which is common but potentially pathogenic.

That lot of chicken salad was disqualified.

# Preflight Monitoring Synopsis

- Few reported clinical infections
  - Dermatitis
  - Urinary tract infection
  - Upper respiratory infection
- Few food contaminants
  - *Salmonella* species
- Common environmental flora\*
- Opportunistic pathogens\*
  - *Burkholderia cepacia*
  - *Pseudomonas aeruginosa*
  - *Staphylococcus aureus*



\*Castro, et al, 2004

# Contamination Potential



**Preflight  
contamination**



**Complex spacecraft  
environments**



**Astronaut activities,  
such as eating and  
hygiene**

# ISS In-flight Monitoring

Surfaces



Air



Water



Quantified in-flight and returned to JSC for identification

# ISS/Mir Summary

- **Uncontrolled water causes surface contamination**
  - Example: Contaminated floating condensate behind panels on Mir
- **Water systems (potable, cooling, etc) are susceptible to contamination**
  - Example: ISS potable water dispenser has required decontamination due to high bacterial levels
- **Microbial contamination is often associated with activities of the crew or operational personnel**
  - Example: Fungal growth on ISS panels resulting from crew hygiene activities



Dust mite and protozoa isolated from Mir floating condensate

# Uncertainty in Risk Assessment



- Alterations in microbial characteristics
  - Virulence
  - Biofilm formation
- Aspects of the immune system have been shown to change
  - The clinical implications are unclear

# Lessons Learned and Best Practices

- **Preflight prevention**
  - Mitigate risk through vehicle design
    - *Employ HEPA filtration of air*
    - *Select microbial resistant materials*
    - *Minimize the formation of condensation*
    - *Use residual disinfectants and filters on potable water systems*
  - Mitigate risk through preflight operations
    - *Health Stabilization Program*
    - *Thorough monitoring of crew, food, air, vehicle/cargo, and potable water*
    - *Implement biosafety review of payloads*
- **In-flight operations**
  - Establish a rigorous housekeeping schedule
  - Monitor vehicle environment and potable water supplies in long duration habitats
  - Provide the capability to clean up contamination