Image source: https://www.nasa.gov/image-feature/scott-kellys-living-quarters

What Living in Space teaches us about Human Health

History of Humans studied in Space

- Only 8 long duration missions to date
- The Human Research Program includes many facets of human space travel such as:
  - Environmental Factors
  - Exercise Physiology
  - Habitability
  - Human Factors
  - Medical Capabilities
  - Psychosocial and Behavioral Health
  - Space Radiation

Image Source: https://www.nasa.gov/hrp/images

Image Source: https://www.nasa.gov/image-feature/nasa-astronaut-christina-koch-works-on-space-botany-research

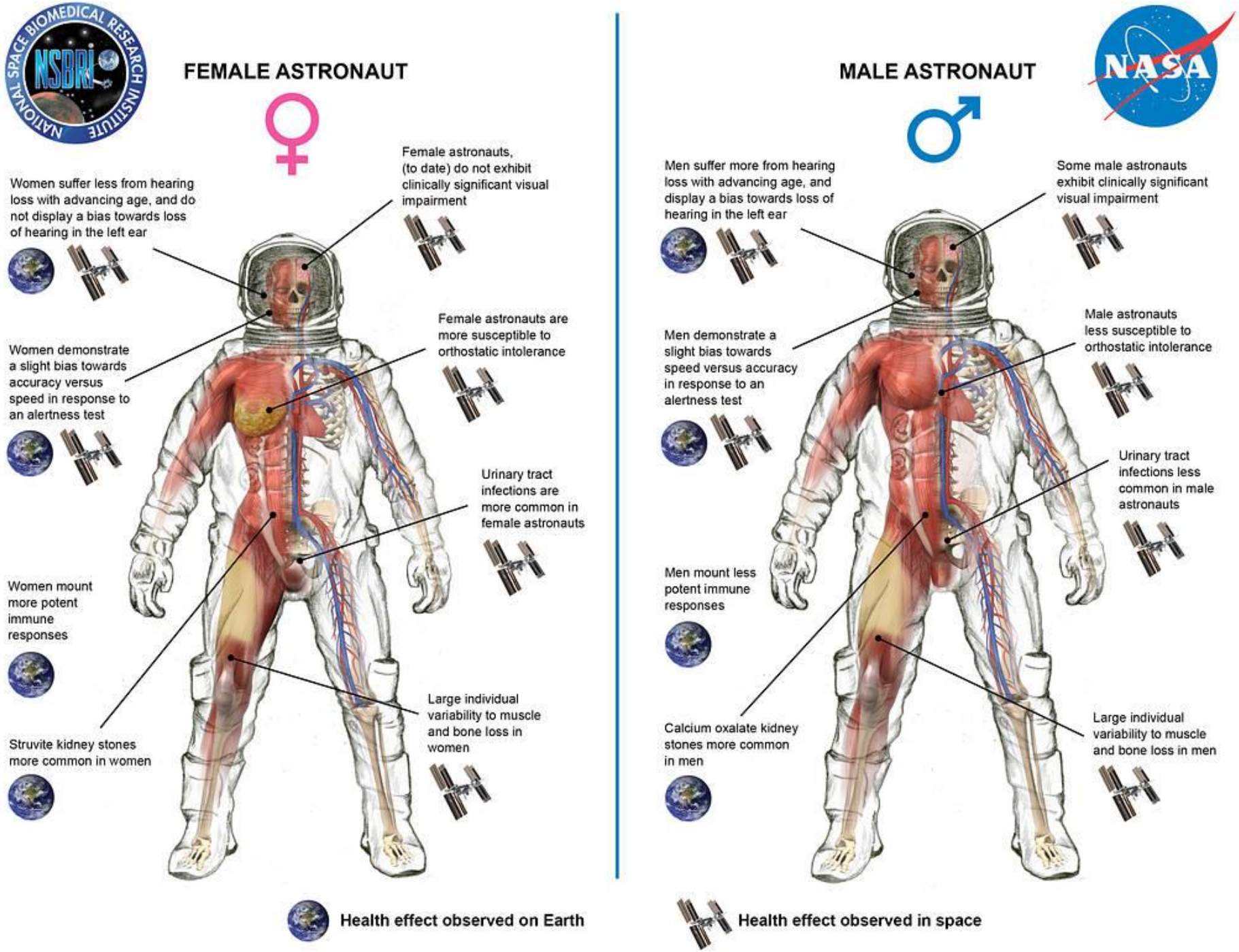
Christina Koch – 11 months in space

- Infographic - https://www.nasa.gov/sites/default/files/atoms/files/kochwheel_011720_me_2.pdf

  Samples archived during the preflight, in-flight and postflight phases of ISS missions provide biosamples for use as a resource for future space flight related research.

Research on:

- Immune system: distribution of white blood cells, particular aspects of innate immunity, and reactivation of latent viruses.
- Musculoskeletal system: Microgravity induces spinal changes similar to those seen in people with limited mobility.
- Contribution of vestibular and proprioceptive information on human wayfinding, and how the brain is responsible for such complex behavior.
- Many astronauts faint or experience lightheadedness upon returning to Earth, which may be related to changes in blood flow in the brain.



Women react better
- Hearing
- Vision
- Immune response

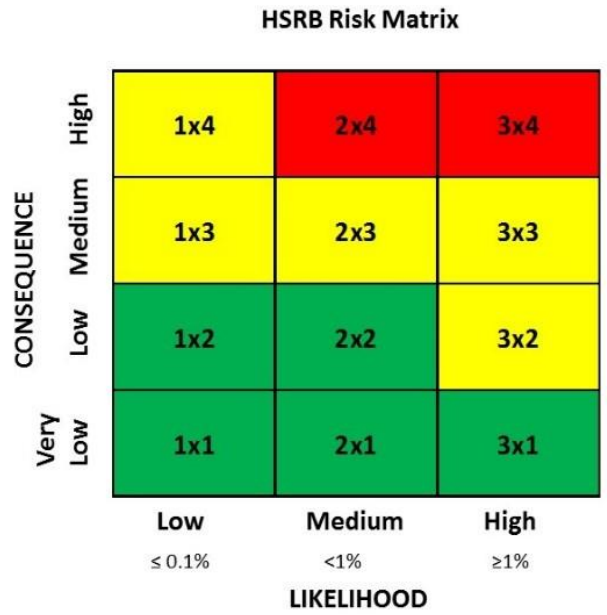
Men react better
- Orthostatic intolerance
- Urinary tract infections

Both suffer
- Muscle & bone loss

Behavioral
- Female bias toward accuracy
- Male bias toward speed

5 Hazards of Human Spaceflight

1. **Radiation**
2. **Isolation and confinement**
3. **Distance from Earth**
4. **Gravity (or lack thereof)**
5. **Hostile/closed environments**



[Human Research Roadmap]

Image source: https://www.nasa.gov/feature/cloudy-with-a-chance-of-radiation-nasa-studies-simulated-radiation

5 Hazards of Human Spaceflight

- **1. Radiation**

- Radiation exposure increases cancer risk, damages the central nervous system, can alter cognitive function, reduce motor function and prompt behavioral changes.
- The space station sits just within Earth's protective magnetic field, so while astronauts are exposed to ten-times higher radiation than on Earth, it's still a smaller dose than what deep space has in store.
- Possibility that they will develop cardiovascular disease, including cerebrovascular, microvascular, and other degenerative tissue effects such as diseases associated with accelerated aging.

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

5 Hazards of Human Spaceflight

- **2. Isolation and confinement**
- Behavioral issues among groups of people crammed in a small space over a long period of time, no matter how well trained they are, are inevitable.
- Sleep loss, circadian desynchronization
- Monitoring behavioral health
  - devices like that help you to assess and improve your sleep
  - Lighting to help you align circadian rhythms

Image source: https://www.facebook.com/ISSNATIONALLAB/photos

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

5 Hazards of Human Spaceflight

Image source: https://spaceplace.nasa.gov/moon-distance/en/

- **3. Distance from Earth**
- The third and perhaps most apparent hazard is, quite simply, the distance. Mars is, on average, 140 million miles from Earth. Rather than a three-day lunar trip, astronauts would be leaving our planet for roughly three years.
- Compared to International Space Station expeditions
  - If a medical event or emergency happens on the station, the crew can return home within hours.
  - Cargo vehicles continual resupply the crews with fresh food, medical equipment, and other resources.
  - Once you burn your engines for Mars, there is no turning back and no resupply.
  - Face a communication delay of up to 20 minutes one way limiting support from their fellow team on Earth.

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

5 Hazards of Human Spaceflight

Image source: https://www.nasa.gov/mission_pages/station/research/news/red_epic_dragon_camera

- **4. Gravity (or lack thereof)**
- Bones, muscles, cardiovascular system have all been impacted by time without standard gravity. When astronauts transition from one gravity field to another, it's usually quite an intense experience.
- NASA is identifying how current and future, FDA-approved osteoporosis treatments, and the optimal timing for such therapies could be employed to mitigate the risk for astronauts developing premature osteoporosis.
- Adaptability training programs and improving the ability to detect relevant sensory input are being investigated to mitigate balance control issues.
- Compression cuffs worn on thighs help keep the blood in lower extremities to counteract vision changes.

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

5 Hazards of Human Spaceflight

- **5. Hostile/closed environments**
- Important habitability factors include temperature, pressure, lighting, noise, and quantity of space.
- Everything is monitored, from air quality to possible microbial inhabitants.
  - Make sure the atmosphere is safe to breathe and not contaminated with gases like formaldehyde, ammonia, and carbon monoxide.
  - Microorganisms that naturally live on your body are transferred more easily from one person to another in a closed environment.
- Extensive recycling of resources we take for granted is also imperative: oxygen, water, carbon dioxide, even our waste.

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

Image source: https://www.nasa.gov/audience/foreducators/stem-on-station/ditl_sleeping

The NASA Twins Study: A multidimensional analysis of a year-long human spaceflight

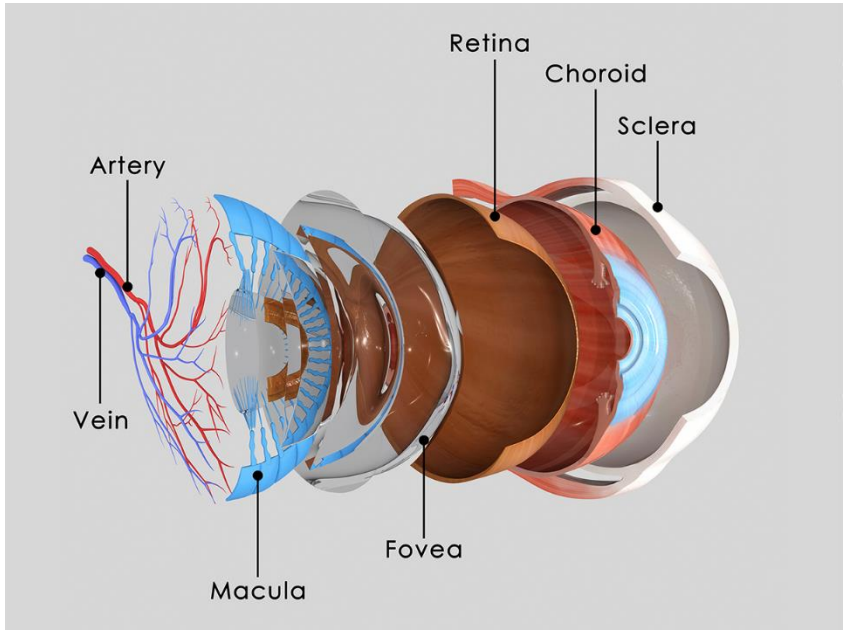
Francine E. Garrett-Bakelman et al. *Science* 12 Apr 2019

- Some biological functions were not significantly affected by spaceflight, including the immune response
- For a few measures, persistent changes were observed even after 6 months on Earth, including
  - some genes' expression levels,
  - increased DNA damage from chromosomal inversions,
  - increased numbers of short telomeres,
  - attenuated cognitive function.

Image Source: https://www.nasa.gov/feature/nasa-s-twins-study-results-published-in-science

The NASA Twins Study, continued

- Changes in multiple data types were observed; the majority of these eventually returned to a preflight state
  - These included changes in telomere length,
  - gene regulation
  - gut microbiome composition,
  - body weight,
  - carotid artery dimensions,
  - choroidal thickness & thining in retina
  - serum metabolites.
- In addition, some factors were significantly affected by the stress of returning to Earth, including
  - inflammation cytokines and immune response gene networks, as well as cognitive performance.



What does all this mean for Human Health?

- Gravity
  - Weight-bearing exercise to keep bones strong
  - HRP may contribute to the development of future techniques for assessing the efficiency of osteoporosis treatments.
  - Cardiovascular effects of impaired circulation – 2013 Spinoff to measure hypoxia
- Radiation
  - 2015 Spinoff - UVA+B SunFriend activity monitor
- Stress
  - The physiological effects of stress last a long time
  - HRP may provide a better understanding of stress responses in healthy humans on Earth.

Image source: https://spinoff.nasa.gov/Spinoff2015/pdf/cg_5.pdf