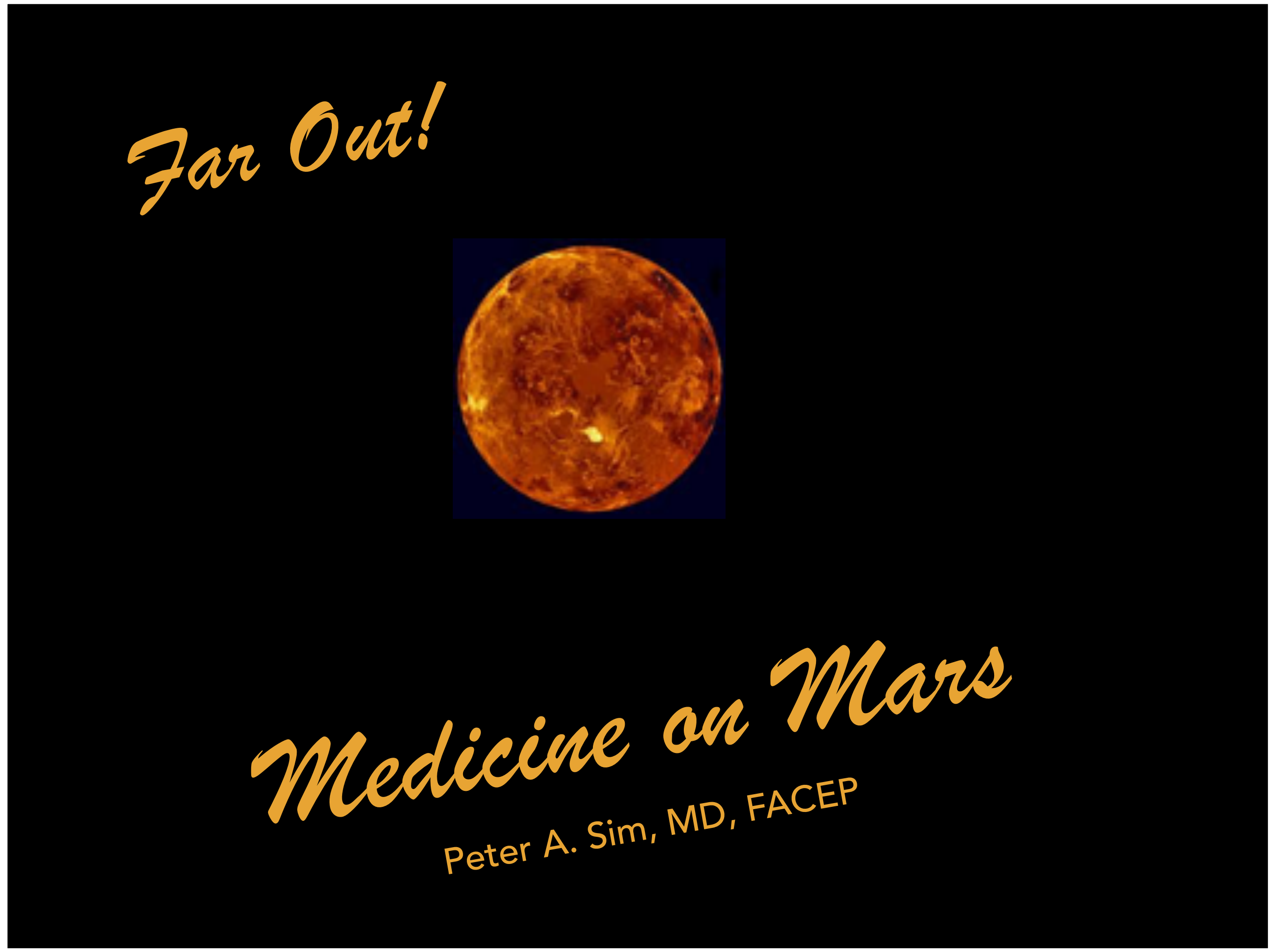


Today we'll be considering a topic that is literally *out of this world*. In fact, it's really . . .

My goal is to give you an . . . associated with . . . living on the Red Planet

My wife, Anna, and I had the amazing opportunity to house-sit on the ranch at PWW for over 6 months last year. Does everyone know where PWW is? I was asked to give a presentation to a Big Island medical conference I've been attending for the past 3 years, and it didn't take long for me to decide that something related to Mars would be my topic.

The ranch sits at 2600 ft elevation, and in addition to being a hub of sustainable and renewable energy research, the sMars habitat on Mauna Loa (and I'll tell you more about that later) was designed here (by Paul Ponthieux), and is monitored in the Energy Lab, just down the hill from where we were staying. So, during our time at the ranch I was able to interact with many Mars-knowledgable and interesting people, including those currently engaged in the HI-SEAS Mission IV.

DR. JOEL LEVINE, PLANETARY AND ATMOSPHERIC SCIENTIST

First, I'd like to acknowledge two individuals who supplied great advice and information as I was putting together this presentation . . .
Dr. Joel Levine happens to be a friend of mine back home in Williamsburg, VA . . .
41 years at NASA Langley RC in Hampton, VA, working almost exclusively on Mars-related projects (Viking 1, July 20, 1976 —> Mars 2020 Rover).

Dr. Joel Levine
Research Professor
Department of Applied Science
College of William & Mary

Prior to joining W & M in 2011, Joel was a Planetary and Atmospheric Scientist at NASA for 41 years, specializing in Mars-related science and missions

WILLIAM & MARY
CHARTERED 1693

W & M, chartered in 1693 by King William III and Queen Mary II, is the second-oldest institution of higher learning in the U.S., after Harvard

BTW, if you google You Tube Joel Levine Mars, you'll find his two very informative TED talks about (what else?!) Mars — worth watching!

Sheyna E. Gifford, MA, MSc, MD

Chief Medical and Safety Officer
and Crew Journalist
HI-SEAS Mission IV
[8/28/2015 - 8/28/2016]

Hawai'i Space Exploration Analog and Simulation
Simulating long duration Mars missions here on Earth

HI-SEAS
HI-SEAS.ORG

The other person I'd like to thank is Dr. . . .
Sheyna has a really interesting and entertaining blog on the HI-SEAS.org website (as do some of the other crew members)

Time to "Take Your Protein Pills and Put Your Helmet On"!

With those preliminaries out of the way, here we go!

“Man must rise above the Earth …
for only thus will he fully understand
the world in which he lives.”
Socrates

“I think the human race has no
future if it does not go into space.”
Stephen Hawking

Humankind has been yearning to explore the heavens beyond our home on Earth for at least 2400 years, as evidenced by the quotes above by Socrates and Stephen Hawking

A NOD TO HISTORY AND 55 YEARS OF MANNED SPACE FLIGHT

First human spaceflight, Yuri Gagarin, a single orbit on April 12, 1961

Project Mercury, 1958-1963, six manned flights.

Project Gemini, 1961-1966, ten flights

Project Apollo, 1961-1975, 12 missions, first moon landing July 20, 1969

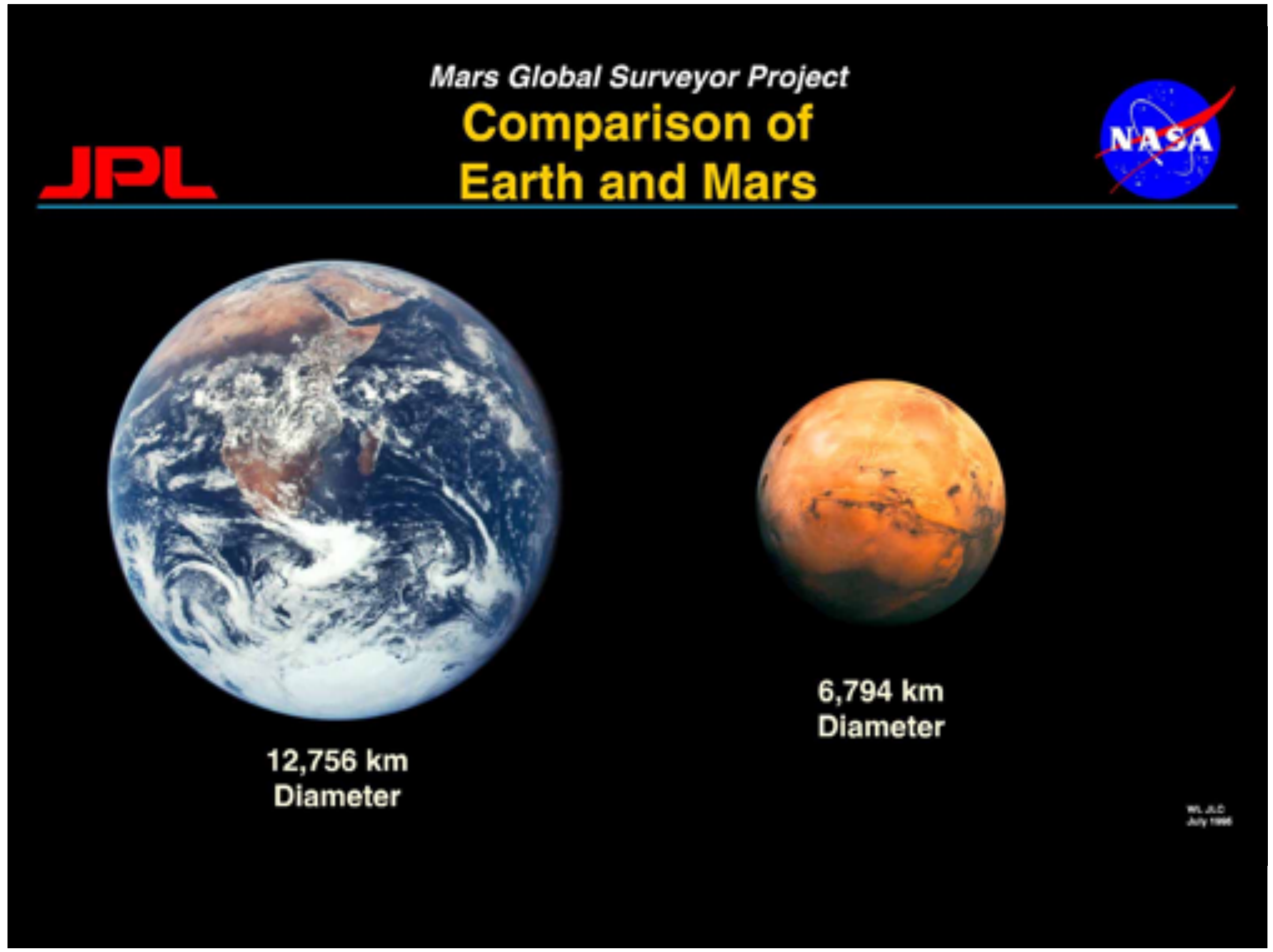
Skylab space station, active 1973-1974

Mir space station, 1986-2001

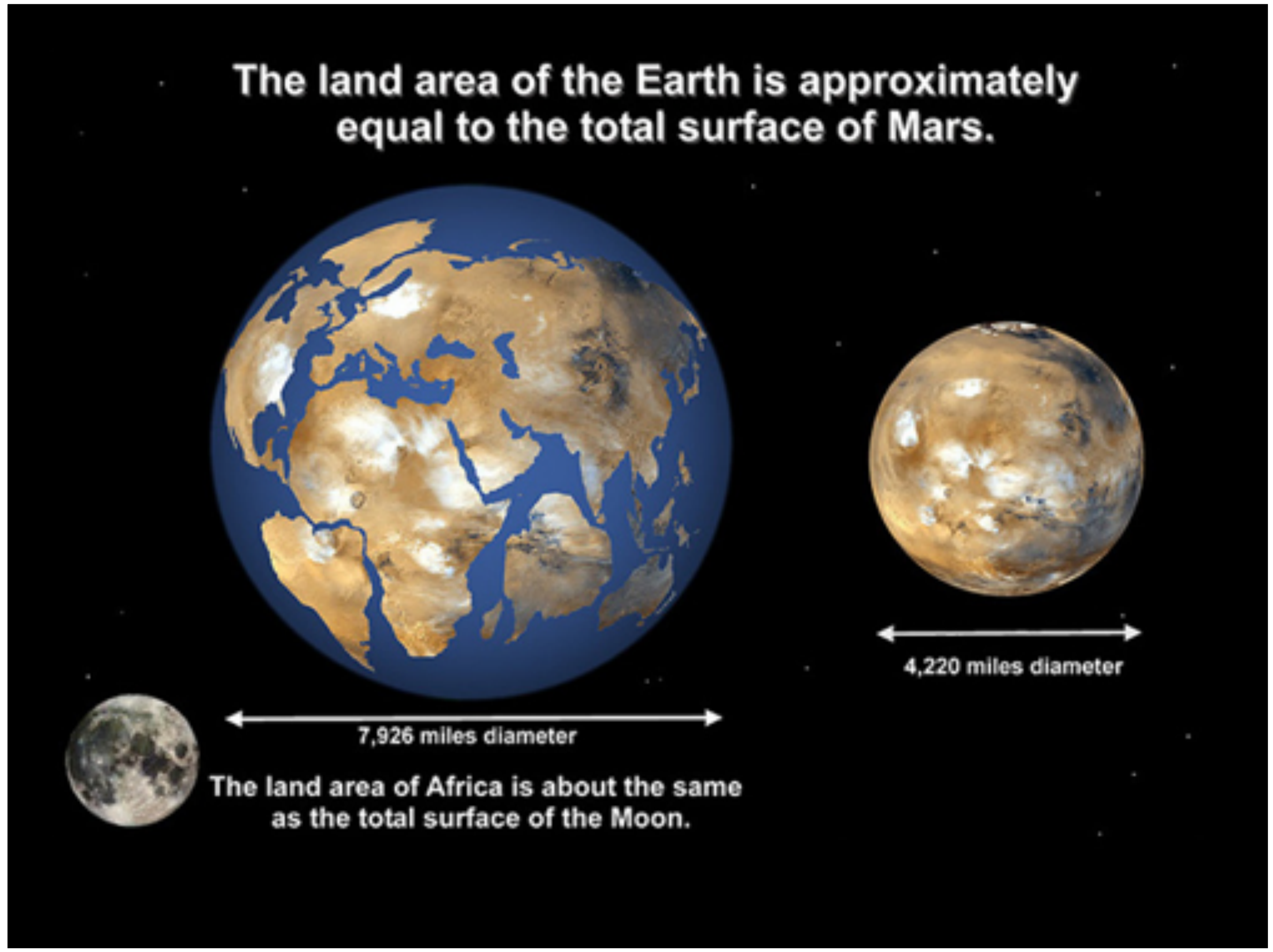
International Space Station, 1998/2000-present

These are some major accomplishments over the history of manned space flight . . .

But let's put the challenge of getting to and living on Mars in perspective. Certainly, a lot has been learned during the past 55 years of manned space flight, since YG made his single orbit of the Earth in 1961. But the single longest duration spaceflight (by a Russian cosmonaut) was just over 14 months, and a Mars mission will be 3 years. The moon is the furthest we've ever been from Earth so far, about a quarter million miles, but Mars is 140 million miles away, on average, or almost 600 times further.

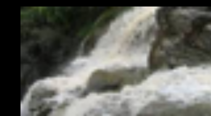
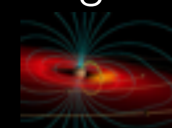


Let's start with some PLANETARY anatomy and physiology, since many of the medical challenges directly relate to the major differences between Earth and Mars



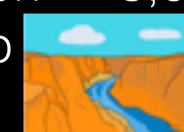
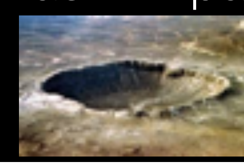
However, the land areas of Mars and Earth are about equal, since Mars currently has no surface water, and 71% of Earth’s surface is ocean.

Key Mars Facts

- Mars was once warm and wet, with fast-flowing surface water like Earth 
- There was once an ocean a mile deep covering much of the northern hemisphere
- There was once a magnetosphere, which has since faded away 
- The “Red Planet” appears red because it is covered with iron oxide (“rust”) dust

- Mars has no active plate tectonics — it’s a “one-plate” planet, but there likely are “*marsquakes*”

Mars Superlatives

- Mars has the largest volcano, canyon, and impact crater in the solar system:
  - Olympus Mons volcano — three times taller than Everest, and as large as Arizona 
  - Valles Marineris canyon — 3,000 miles long, and over 4 miles deep 
  - Hellas Basin impact crater — 2,000 miles across 

In the entire solar system, Mars has the **largest volcano** . . . the **longest and deepest canyon** (dwarfing the Grand Canyon) . . . and **the biggest impact crater** (the day that happened was a bad day on Mars!)

Why Humans? Human Explorers vs Robots

- Provided human explorers arrive on Mars in good physical and mental condition, they should be far more adaptable and efficient than rovers

- It's been estimated that a human explorer on Mars can accomplish in 2 hours what it would take a robot 6 months to do

- It took the Opportunity rover 11 years to cover a marathon distance (26.2 miles) — a human could cover that distance in a day or less.

"Because it's there!"

COMPARING EARTH AND MARS

- MASS: <u>Mars' total mass is 11% of the Earth's</u>
- DENSITY: <u>Mars' density is 71% of the Earth's</u>
- GRAVITY: <u>Mars gravity is 38% of the Earth's</u>
- SUNLIGHT: <u>Mars receives 56% less sunlight</u>
- LENGTH of DAY: Earth 24 hrs., Mars 24 hrs. 37 mins.
- LENGTH of YEAR: Earth 365 days, Mars 686 (667 sols)

Gravity — we could all likely dunk the basketball on Mars!

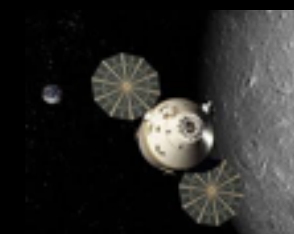
COMPARING EARTH AND MARS

- MILES from Sun: Earth 93 million, Mars 142 million
- AGE: Both are approximately 4.6 billion years old
- ATMOSPHERIC PRESSURE: Earth 1013 mb average, Mars 7.6 mb (Mars has about 1% of Earth's atmospheric density)
- ATMOSPHERIC GASES: Earth 78% N, 21% O2; Mars 95% CO2
- TEMPERATURE: Earth 57 F average, Mars -81 F average Martian surface temperatures range widely from as little as -207 F at the winter pole to almost **80 F** on the day side during summer.

Dust storm portrayed in "The Martian" was not accurate . . .
But don't pack your sunscreen and beach towel — you'll be in a spacesuit.

MAJOR RISKS OF LONG-TERM SPACEFLIGHT AND MARS HABITATION

- Reduced gravitational environment
- Isolation of a small group of astronauts living in a totally mechanical environment, with altered light/dark cycles
- Food and resource recycling in a closed environment
- High particulate radiation exposure
- Possible toxic Martian dust exposure
- Rescue and repair severely limited by distance from Earth
- Lack of complex medical care



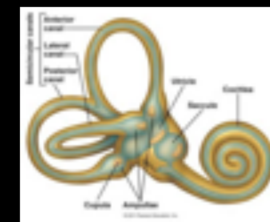
We'll be going into each of these in greater detail . . .
There is no trash pick-up every Wednesday morning
We can't call AAA when the spacecraft has a problem
And there is no 911, or Code Blue team

GRAVITY:
THE EFFECTS OF A MICRO-G ENVIRONMENT

- Vestibular function and proprioception are altered
- Fluid redistribution and circulatory changes
- Bone and muscle deterioration
- Visual degradation
- Other physical effects

Here are the major effects of a micro-G environment — we'll discuss each in more detail. So far, man has been exposed to 1 G, zero G, and 17% G (on the moon). Mars will be 38% of Earth's gravity.

MICRO-G EFFECTS ON VESTIBULAR FUNCTION & PROPRIOCEPTION



- Zero/reduced gravity —> otoliths "float" —> vestibular dysfunction —> vertigo, N/V
- Positional vertigo can last for days, until adaptation occurs
- Proprioceptors and pressure receptors don't send expected spatial information

On Earth, we live in a "downward-pulling" world.
It's felt that at least 15% of Earth's gravity is necessary for the vestibular system to function.
BTW, vomiting in a spacecraft is a real mess, but vomiting inside your helmet can be lethal!
Our proprioceptors, which give us information on the position of our limbs in space based on joint angles, muscle length and muscle tension, aren't operating in the usual fashion because we aren't using our muscles like we would on Earth (to maintain posture, walk, etc.).
The pressure receptors in our feet and ankles don't remind us which way is "down"
About half of all astronauts suffer from "Space Adaptation Syndrome", including nausea and disorientation.

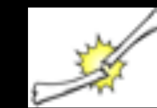
MICRO-G EFFECTS ON FLUID DISTRIBUTION & CIRCULATORY CHANGES

- The hydrostatic pressure gradient along the vascular tree produced by Earth's gravity plays a significant role in the regulation of circulatory function
- In micro-G, lower extremity and torso blood volume is redistributed more superiorly —> facial swelling, nasal congestion, headache, likely increased ICP
- Body senses a fluid surplus —> about a liter of fluid diuresed over the first 2-3 days —> relative dehydration and hemoconcentration —> decreased RBC synthesis, and mild anemia develops over months

On Earth our lower extremity and torso blood volume is regulated and maintained primarily by gravity. Take away gravity and . . .
Photos of astronauts in space often reveal facial puffiness, and they may have symptoms similar to a chronic head cold.

MICRO-G EFFECTS ON BONE & MUSCLE

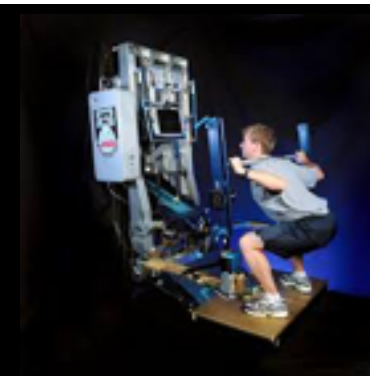
- No/less gravity —> less stress on bones, muscles, tendons, ligaments —> less active remodeling



- 1-1.5% loss of bone mass per month means higher fracture risk (and associated hypercalcuria increases risk for kidney stones)

- Muscles atrophy, and lose mass at rate of 5%/week
- After months in zero G, a “slouched” posture develops, and standing straight requires conscious effort and strain
- Diligent exercise helps, but does not eliminate these changes

Bones, muscles, and tendons respond to the constant pull of gravity and weight-bearing on Earth by changing their architecture in order to resist the gravity force vector. (Bed rest results in bone loss and muscle atrophy.)
Urinary Ca++ excretion increases by 60-70% in the first few days of weightlessness and continues, which translates into a steadily higher risk of fracture and kidney stones on long missions. Fracture healing will likely be delayed in micro-G. So far, there have been no reports of stone passage (ureteral colic) during a mission.



NASA's Advanced Resistive Exercise Device (ARED) investigation on the ISS uses a piston and flywheel system to simulate free-weight exercises in normal gravity to work all the major muscle groups through squats, dead lifts, and calf raises

Our study is still ongoing; however, early results suggest that astronauts can reduce the risk of bone loss and renal stones by proper intake of appropriate nutrients, such as calcium and vitamin D, an effective exercise program and minimal amounts of medication [a bisphosphonate, such as alendronate].

Preventing Bone Loss in Space Flight | NASA

www.nasa.gov/mission_pages/station/research/.../bone_loss.html

ARED onboard the ISS since 2008. Accommodates all crew, regardless of size, and allows customized workout.

ARED 2.5 hours per day + good nutrition + bisphosphonate (like alendronate [Fosamax]) —> reduced (but did not eliminate) bone and muscle loss

Alternating days of HIIT with continuous aerobic exercise is most effective regimen for maintaining CV fitness

MICROGRAVITY EFFECTS ON VISION

- "Space blindness", a steady degradation of vision, worsens with duration of time in space
- 30% of astronauts are affected on short-term missions, double that frequency on long-duration missions
- Early astronauts would not report their visual difficulties, for fear of being grounded
- Currently thought to be due to papilledema secondary to fluid redistribution and increased ICP

- Elevated CO_2 levels inside spacecraft and radiation effects could be contributory
- *A potential mission-compromising problem with long interplanetary voyages*

On Earth, we maintain our balance and spatial orientation by integrating input from 3 distinct sensory modalities (ask audience what those 3 are): the vestibular system (motion, equilibrium, spatial orientation), proprioception (touch), and vision (sight). Now we know that all 3 are adversely affected by microgravity, which is obviously not a good situation!

OTHER EFFECTS OF MICROGRAVITY

- Some astronauts have noted a change in taste when in space
- Odors quickly permeate the environment

- Tears cannot be shed when crying, because they stick together into a ball
- Molting: without gravity and pressure on the feet, foot callouses outlive their usefulness and are sloughed after a couple months

These miscellaneous effects are obviously not mission-compromising . . .

RETURNING TO GRAVITY

- The change from weightlessness back to gravity is a physiologic shock and major physical challenge
- Exits from capsules and shuttles are usually hidden from direct observation for a reason
- As a general rule: each day in space requires a day of recovery upon return to Earth's gravity
- But with appropriate rehab, bones and muscles can return to their normal strength

What's it like coming back to gravity? It's a very difficult and lengthy transition!

RETURNING TO GRAVITY

ANDREW THOMAS
141 DAYS ABOARD MIR, 1998

ARTIFICIAL GRAVITY ON TRIP TO MARS?

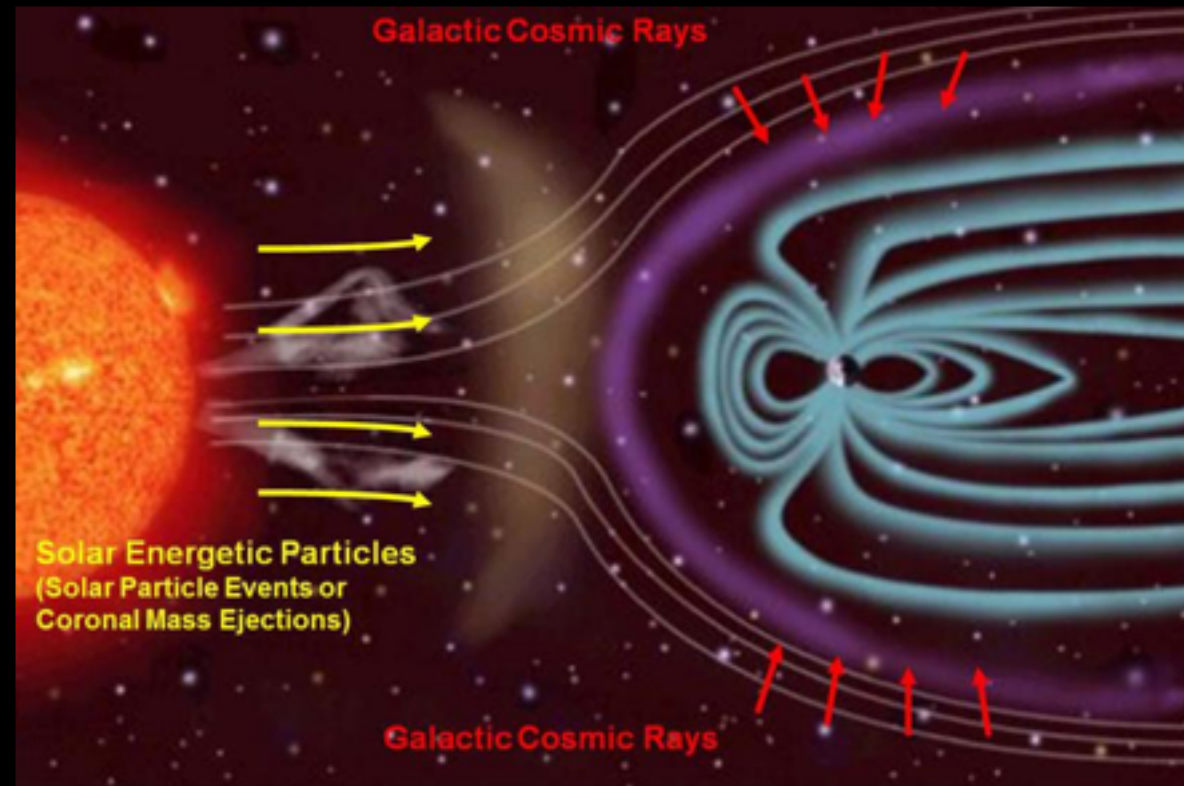
- Possible (though unlikely) solution, with gravity generated by spinning spaceship, or a “G-room”, or “G-chair”
- Would require “dual readaptation” — brain and vestibular system would have to become comfortable with alternating periods of gravity and zero gravity (similar to putting on/taking off one’s glasses)

Could we mitigate *all* the gravity-related issues we’ve discussed by creating an *artificial* gravity environment in the spacecraft? Although very expensive, ultimately, this could be the best long-term solution.

Hermes, the spinning spaceship in “The Martian”

Andy Weir has argued forcefully that artificial gravity is the best way to assure astronaut health and safety during long voyages, and I personally think he’s correct

RADIATION: *SOLAR PARTICLE EVENTS AND GALACTIC COSMIC RAYS*



Moving away from gravity issues, and on to another large problem: radiation.

MARS' WEAK MAGNETIC FIELD MEANS LITTLE PROTECTION FROM PARTICULATE RADIATION

- Where Mars does have a magnetic field, it's mostly in the crust of the southern hemisphere, and about 1/40th as strong as Earth's
- An astronaut on Mars will not be protected by the radiation-shielding effects of a strong magnetosphere and an atmosphere like we enjoy on Earth
- It is likely that most of the early Martian atmosphere was lost to space because Mars has no substantial intrinsic magnetic field to protect the atmosphere from solar wind scavenging

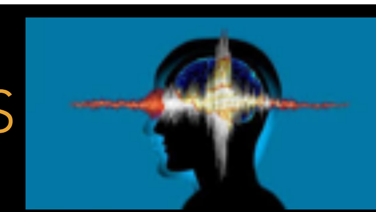
NASA's MAVEN spacecraft now orbiting Mars estimates the planet is losing 100 grams (1/4 pound) of atmospheric gases (O_2 and CO_2) every second to the solar wind (a constant stream of charged particles shooting away from the sun at 1 million mph). Big solar storms (SPE's) travelling at twice that speed would increase the escape rate by 10-20 times or more.

SOLAR PARTICLE EVENTS

- AKA solar proton event (SPE) or "proton storm"
- Massive random storms on Sun's surface —> high energy particles and radiation broadcast into space
- Outside of protective shield of the Earth's magnetosphere, a fatal radiation dose could occur in minutes
- But, on Mars we should have days of warning to head underground (lava tubes)
- 1972 "superstorm" *between* Apollo 16 & 17, would have caused skin blistering, N/V at a minimum
- Polar ice data indicate we are living in a relatively mild period of solar activity

Had our astronauts been en route to or on the surface of the moon during the 1972 "superstorm" — or similar events in 1956 and 1989 — they would have experienced massive doses of radiation. Their skin would have burned, blistered, and peeled, they would have experienced nausea and vomiting, and in all likelihood, they would have been killed.

GALACTIC COSMIC RAYS



- Nuclei of heavy atoms (mostly iron) traveling at close to the speed of light
- Penetrate deeply into the body (even through the skull)
- Very high energy results in numerous breaks in both strands of the DNA helix, and the body has evolved no way to repair this damage
- A constant, low-level background radiation
- When solar activity is low, galactic cosmic rays more easily enter the solar system
- Shielding is problematic — could increase damaging particles

On Earth x-radiation and UV sunlight will cause single breaks in one strand of our DNA, which is repairable.
Galactic cosmic rays hitting shields could knock even more ions out of the shielding material, leading to a cascading increase in damaging particles.
In deep space and on Mars, we have neither mechanical or biological defenses against cosmic rays.

GALACTIC COSMIC RAYS

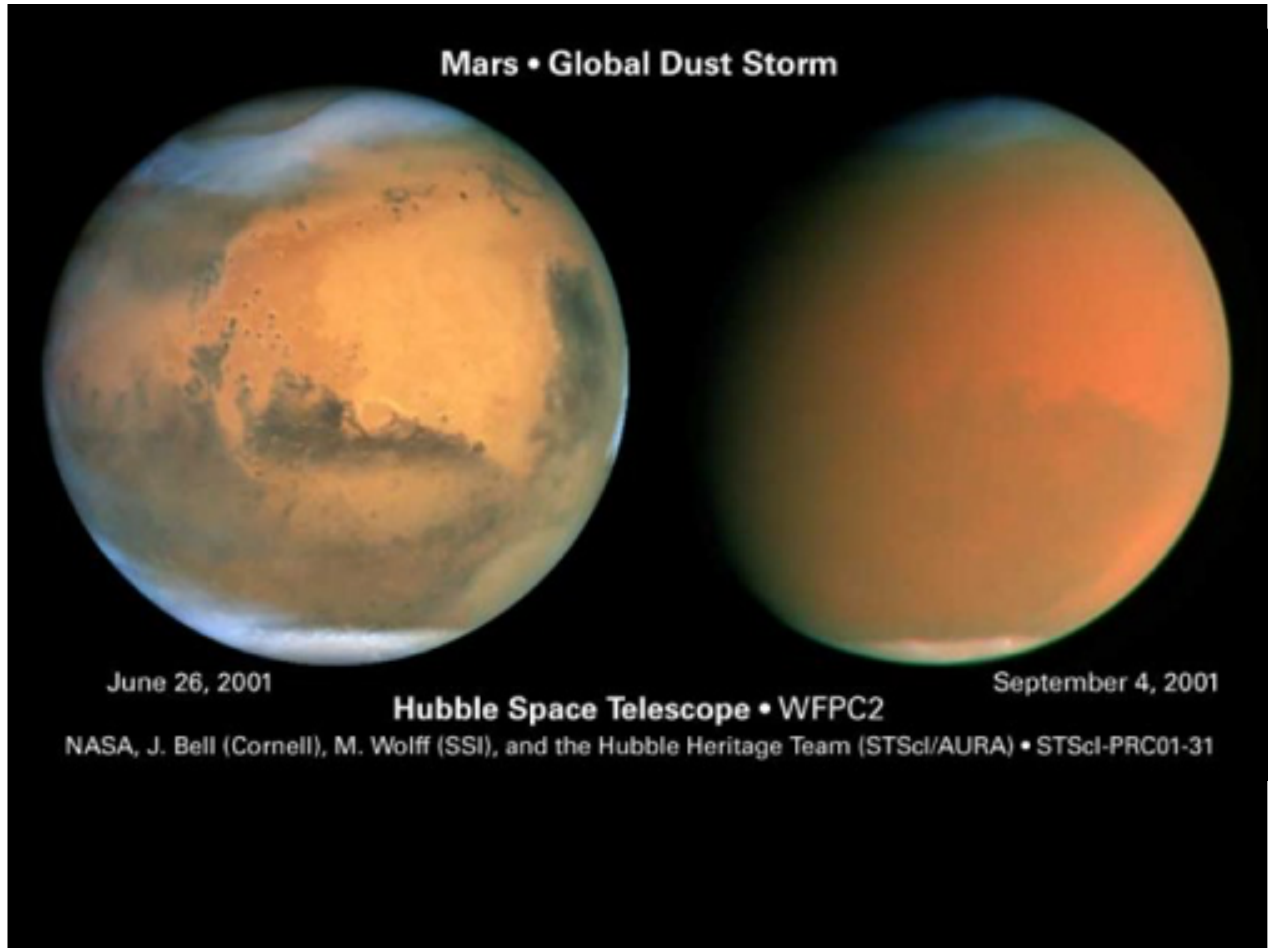
- Mice exposed to artificial cosmic rays in linear accelerator —> numerous “buckshot” brain lesions, altered dopamine pathways, apathy, and less memory
- Cosmic rays could cause mutations in our human microbiota, and microorganisms resident in spaceship —> potential for pathogenicity
- Curiosity calculated an average dose over a 180-day, one-way journey to Mars as 300 mSv, the equivalent of 24 CAT scans. This is more than 15 times the annual radiation limit for a worker in a nuclear power plant
- There is an increased risk of cancer associated with a trip to Mars of approximately 5 percent over a lifetime. OSHA’s occupational limit is a 3 percent increase, so it is currently *illegal* for NASA to send humans to Mars

- See more at: http://www.astrobio.net/news-exclusive/calculated-risks-how-radiation-rules-mars-exploration/#sthash.IxOIHxrl.dpuf

T-cell deficiencies have appeared in “astronauts” isolated on analogue missions in Antarctica.

The Commercial Spaceflight Federation is hopeful for an “informed consent” process, where as long as the spaceflight participant is aware of the risks involved in the flight, the FAA (or NASA) won’t have any regulations preventing whoever wants to fly from going.

Dust storms are ubiquitous on Mars. There are "local" storms (hundreds of miles across), "regional" (thousands), and "global".
Once every three Mars years (about 5 ½ Earth years), on average, normal storms grow into planet-encircling dust storms, and we usually call those 'global dust storms' to distinguish them.
Dust storm depicted in "The Martian" not realistic. Astronaut Mark Watney (Matt Damon) was struck by antenna, but the actual wind force on Mars would feel like a gentle breeze to us.



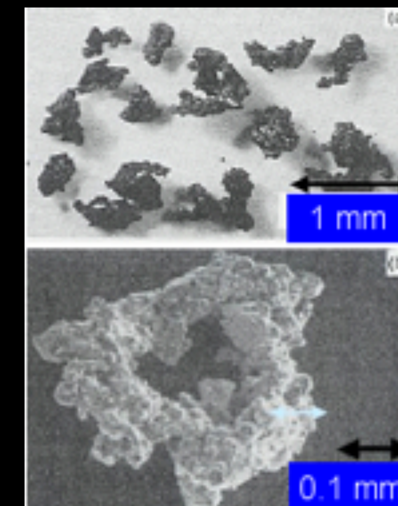
In the space of about 2 months in 2001 Mars was enveloped in a global storm.

WHAT WE KNOW FROM APOLLO PROGRAM EXPERIENCE WITH LUNAR DUST

- Moon's surface covered in regolith (loose, heterogeneous superficial material covering solid rock), the result of meteorite impacts and ancient volcanic explosions
- 80% of the regolith is composed of *micron-sized* dust particles that stick to every surface, with properties similar to silica
- Apollo astronauts found moon dust quickly coated interior of lunar module (and spacesuits, bodies, and hair)

DON'T BREATHE THE MOONDUST!

- The microscopic, floating lunar dust particles are easy to inhale
- Coughing may do little to dislodge the dust particles
- May cause a silicosis-like syndrome with enough exposure (?)
- May act like asbestos fibers, increasing cancer risk (?)
- Apollo 17 crew's experience, December '72



April 22, 2005

In 1972, Apollo astronaut Harrison Schmitt sniffed the air in his Lunar Module, the *Challenger*. "[It] smells like gunpowder in here," he said. His commander Gene Cernan agreed. "Oh, it does, doesn't it?"

The two astronauts had just returned from a long moonwalk around the Taurus-Littrow valley, near the Sea of Serenity. Dusty footprints marked their entry into the spaceship. That dust became airborne--and smelly.

Later, Schmitt felt congested and complained of "lunar dust hay fever." His symptoms went away the next day; no harm done. He soon returned to Earth and the anecdote faded into history.

MARTIAN DUST COULD BE WORSE

- The Red Planet is red because it is covered in a very fine iron oxide dust, with a static electrical charge
- The dust also contains fine silicate materials, perchlorates (damage thyroid), gypsum (may cause illness similar to "black lung"), and trace amounts of arsenic and hexavalent chromium
- Martian storms generate significant static electricity, and could be capable of splitting carbon dioxide and water apart. Elements could then form H2O2 and fall to the ground as a "snow", concentrating in the top layers of Martian soil, preventing life from surviving at the surface
- Contact with the highly oxidative and chemically reactive dust could corrode rubber and plastics, burn human skin

BUT, . . .

MARTIAN DUST COULD BE WORSE

- "Sticky" electrostatic dust will adhere to spacesuits during EVA's, contaminate airlocks, and likely get into astronauts' living space, where it would be inhaled

- Corrosive and abrasive dust also a hazard for mechanical systems [after 3 days of Apollo EVA's, lunar dust in/on spacesuit bearings created great difficulty in movement, and another EVA would not have been possible]

- Potential electrical arcing during entry, descent and landing, and take-off, ascent, and orbital insertion

- This summer/fall: 3-day NASA-sponsored "Workshop to Investigate Dust in the Atmosphere of Mars and Its Impact on the Human Exploration of Mars", at Johnson Space Center

IMMUNITY AND INFECTIONS IN SPACE

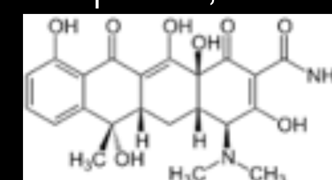
- Immune system becomes “dazed and confused” during spaceflight
- Stress, radiation, microbes, microgravity, altered sleep cycles and isolation all have a negative effect on immune system
- Immune system cell function is altered, becoming either more or less active
- Cytokines (proteins that help regulate immunity) undergo changes in concentration that persist during flight
- Latent/dormant viruses (CMV, EB) may reawaken, with no symptoms if immune system is depressed, but exaggerated symptoms if immune system then reacts excessively

IMMUNITY AND INFECTIONS IN SPACE

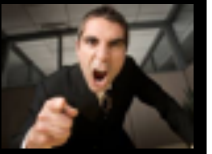
- 234 different species of bacteria and fungi were found living alongside astronauts on Mir space station

- A significant number of microbial infections (acute respiratory illnesses, conjunctivitis, dental infections) were reported by Mir astronauts 1995-1998

- Antibiotics less effective in space, and needed in higher concentrations



PSYCHIATRIC AND SOCIAL CONCERNS



- Working and living in space is a highly stressful experience
- *Getting there*: involves riding on top of what amounts to a giant firecracker, transitioning from 3 times normal gravity during launch, to zero gravity
- *Being there*: involves confinement in a small space, relatively primitive living conditions, and isolation from one's family and friends

There won't be internet, Face Time, or FaceBook.

PSYCHIATRIC AND SOCIAL CONCERNS

- Prior experience has shown that during long analogue missions in harsh isolated environments, >10% of subjects will develop significant psychological adaptation problems
- Can't depend on self-reporting — remember, these are astronauts

- About 3% will develop symptoms of a true psychiatric disorder, like major depression
- Given the communication delays, a typical psychiatrist/patient dialogue that might reveal changes in mood, mental issues, etc. not possible
- Russian astronauts on missions >4 months had propensity to develop asthenia (tiredness, loss of strength, mood swings)

PSYCHIATRIC AND SOCIAL CONCERNS

- Variable light/dark cycles and mission demands —> disrupted circadian rhythms and poor sleep (50% of shuttle astronauts took sleep aids and still got 2 hours less sleep per night)
- Sleep deprivation —> profound effects on level of fatigue, alertness, and mental clarity
- Increased background sound levels from fans required to process environmental atmosphere
- Claustrophobia
- Monotony
- Different cultural backgrounds of crew adds complexity

Disturbances in circadian rhythm have profound effects on the neurobehavioural responses of crew and aggravate the psychological stresses they already experience. Sound levels in the station are unavoidably high because the cabin atmosphere is unable to thermosyphon in a zero-G environment; fans are required at all times to allow processing of the atmosphere, which would stagnate in zero-g).

Exhaustion can obviously lead to impaired judgement by astronauts. NASA has developed cognitive assessment tools. Baseline values are established by testing before flight, and the test can be re-administered periodically to monitor any cognitive changes.

PSYCHIATRIC AND SOCIAL CONCERNS

Early Lessons

- There have been several almost-mutinies by astronauts in the past

- December 1973: Skylab space station crew conducted a strike, becoming hostile and aggressive towards Mission Control. Issues were tight scheduling, being treated like robots, and being forbidden from their favorite activity — looking out the window (!)

THE “OVERVIEW EFFECT”
FRANK WRIGHT, 1987

- A beneficial result of manned space flight
- Describes the feeling astronauts experience when seeing the Earth far below them:
    - spiritual epiphanies such as unity with nature, transcendence, and universal brotherhood
    - a deep sense of wonder and awe about the universe and our planet
    - a renewed sense of responsibility for taking care of our earthly environment
    - these positive effects seem to last — returned astronauts are less aggressive, anxious, depressive, or hypochondriacal

Ah, the Overview Effect, an apparent beneficial effect of manned space flight.

911 — SPACE EMERGENCIES

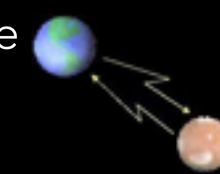
- Data from extended-duration missions in close quarters (like submarines) show a 6% chance/year that an individual will experience a medical or traumatic incident requiring emergency care
- On a three-year round-trip voyage to Mars with six astronauts it becomes quite likely that at least one such emergency will occur
- The risk in deep space or on Mars, with microgravity, dust and radiation, would be even greater
- Evacuation to a higher level of care not an option

Chris Flynn, NASA flight surgeon and Chief of Psychiatry at the Johnson Space Center: "There is a very small E.R. up there. What we can do, even as a physician on board, is quite limited."

Between 1988 and 1995 there were 279 men and women in space missions. All but 3 became ill during a space trip. 175 biomedical risks identified by NSBRI and NASA; 4 were categorized as Type 1 or "grave", meaning no good protective measures exist, and they are very likely to occur.

NOT TO MENTION . . .

- Mission Control cannot be of immediate help (20 minute communication delay each way), so the physician will be "winging" it on her/his own



- Anesthesia, blood flow, wound healing, and recovery will all likely be altered from prior experience
- NASA: All crew members should have Level V (physician level) training for common, <u>treatable-in-space</u> emergencies — what if the doc goes down?!

PROBLEMS FOR THE SPACE DOC IN ZERO G

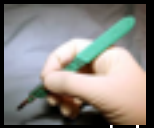
- Even with good general surgical and ED skills, routine procedures will not be the same in space

- No safe way to give oxygen, or make and administer fluids
- External blood aerosolizes and becomes a floating fog
- The physician's tactile "feel" would be very different from his earth-bound experience, due to the lack of gravity

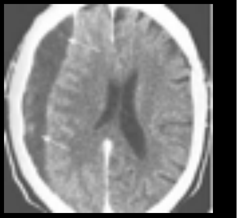
    - Natural and intuitive earthly cues are absent
    - Instruments have no weight
    - Tissue density and resistance are altered

SPEAKING OF SURGERY . . .

- With limited resources, *any* surgery would be a great risk, especially surgery of significant complexity



- In major limb trauma, immediate amputation might be the choice over attempts to repair the damage



- Head trauma would be particularly problematic. "Neurosurgery at zero G is unimaginable to most experts," says Dr. Jon Bowersox, surgeon at UCSF who works with N.S.B.R.I., former Army flight surgeon, and expert on adapting surgery to the battlefield
- Simply put, there is currently no such thing as life support in space

Neurosurgery in space won't be happening anytime soon, so a fall with a resultant epidural hematoma would likely end with uncal herniation and death of the astronaut.

A (NON-COSMIC) RAY OF HOPE

- Technological advances will likely come to the partial aid of Space Doc
- A series of embedded or attached sensors in/on crew members could provide a comprehensive and continuously updated picture of the entire crew's real-time physiology — ? early warning
- Artificial intelligence might monitor complex events (like Major Tom's MI), or procedures/surgery

. . . like Major Tom's MI

SPACE MEDICINE EXPLORATION MEDICAL CONDITION LIST, NASA

- Lists 86 medical conditions, from “abdominal injury” to “visual impairment/intracranial hypertension”
- For each condition, recommends “shall” treat, “should” treat, or “not addressed”, based on eight distinct mission profiles from 3 days to 6 months
- “Not addressed” examples: cariogenic shock, acute glaucoma, head injury, shoulder dislocation, surgical treatment . . .

Conditions are more likely to be addressed on longer missions

NASA *HUMAN RESEARCH ROADMAP*

- This is a sobering list of 304 "gaps" in current knowledge related to human physiology and space missions. Some examples:
    - “We do not have the capability to provide medical suction and fluid containment during exploration missions
    - “We don’t understand how the spaceflight environment affects bone fracture healing in-flight
    - “Are nutrients in food stable during spaceflight?”
    - “What are the effects of spaceflight on pharmacokinetics and pharmacodynamics

I came away from reading this list saying “wow!”, we really do need to know the answer to this question, or have that capability, or have that information before we venture off to Mars!

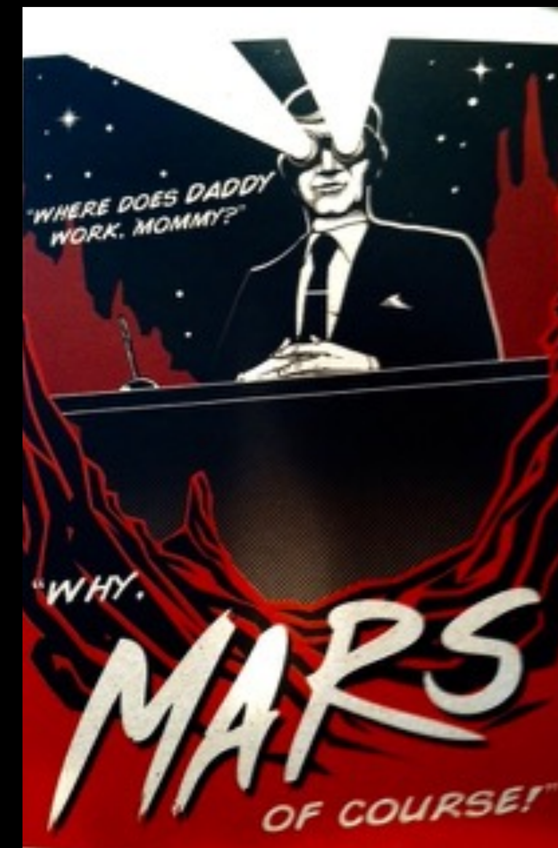
TO SUMMARIZE — TRAVEL TO MARS PRESENTS NUMEROUS CHALLENGES, AMONG THEM ARE:

- Microgravity
- Radiation
- Dust
- Medical, Surgical, and Psychiatric care
- Immune system alterations
- And more . . .

In summary, I hope I’ve been able to give you an expanded understanding of the issues related to deep space travel and living on Mars

To Conclude:
Humans *Will* Colonize Mars — It’s Just a Matter of Time . . .

But We Have a *Lot* to Learn Before We Can Make Mars Our Second Home



And to conclude
But, I hope you now appreciate how much we have to learn

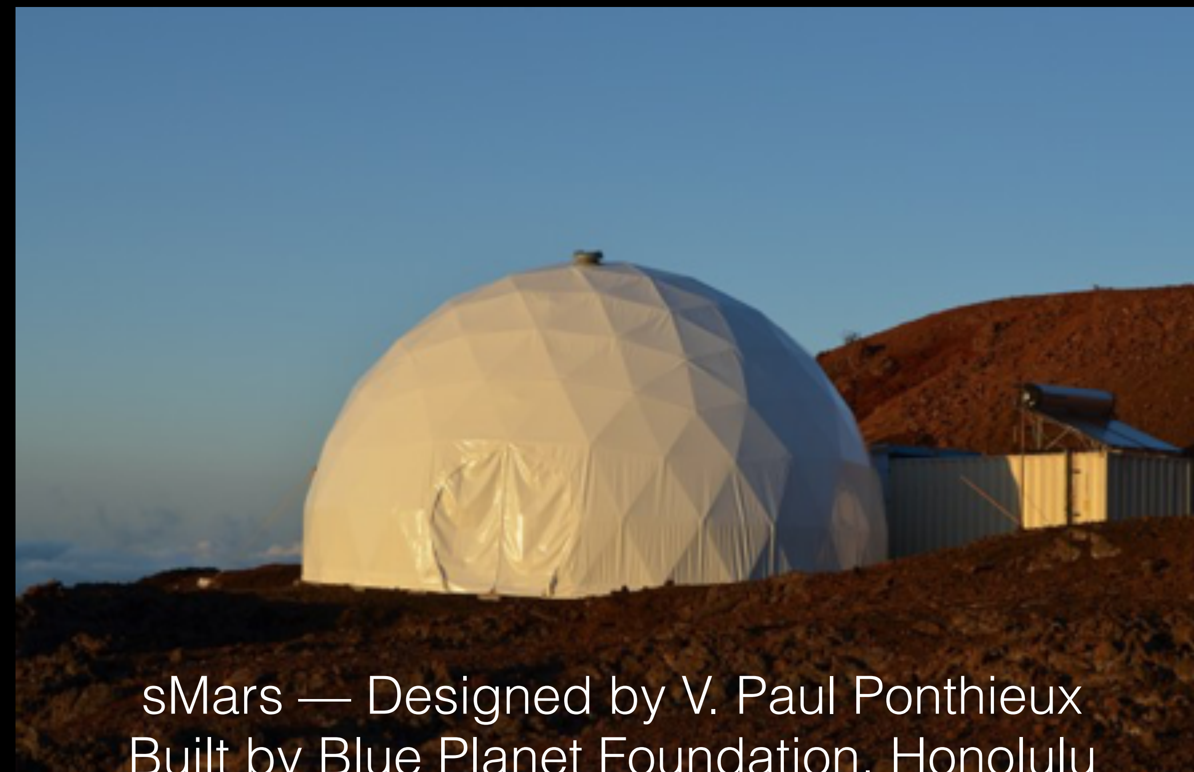
So — who's ready to sign up for the first trip to Mars?

[redacted]

[redacted]

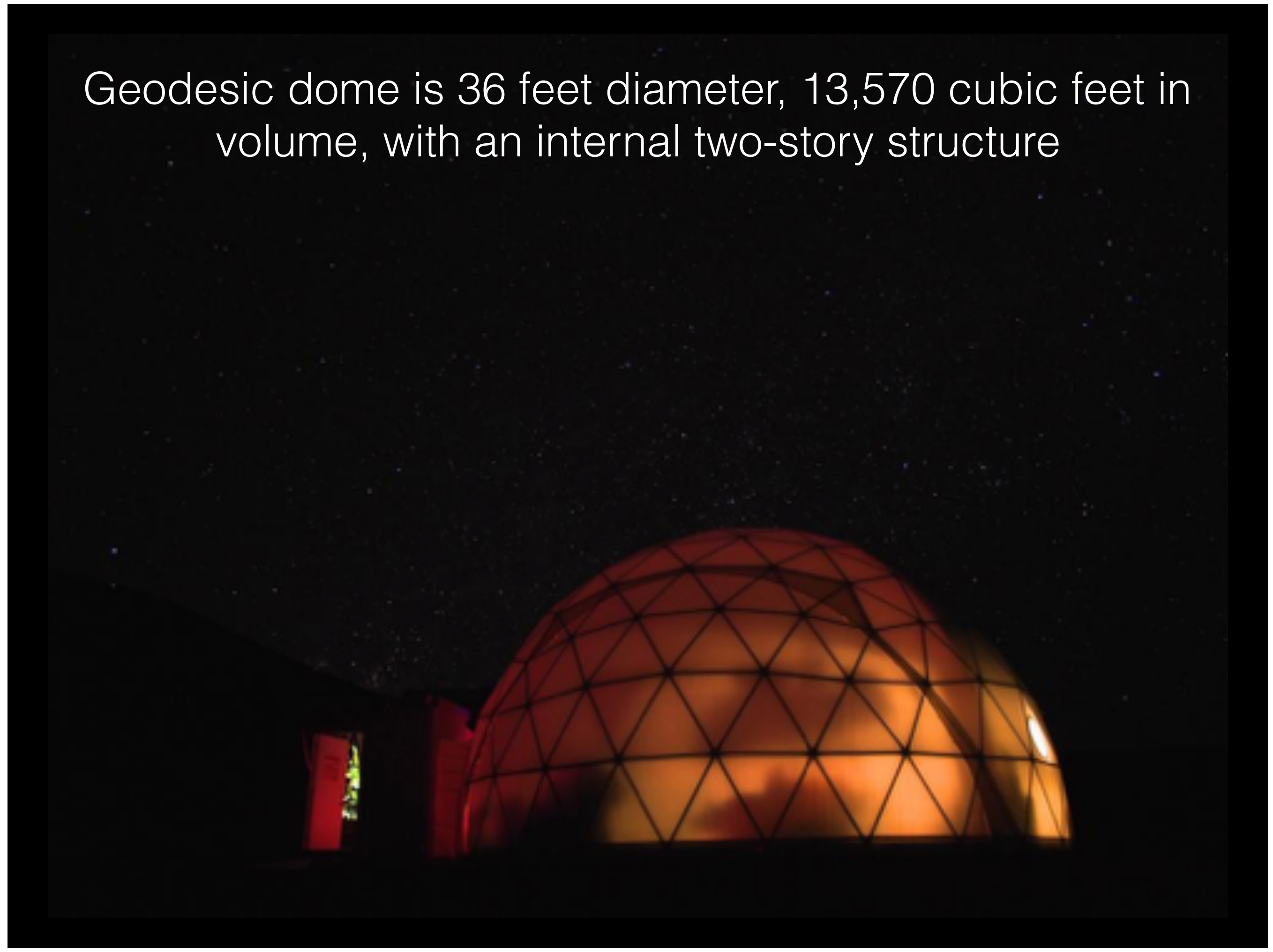
HI-SEAS stands for . . .
Funded by NASA Human Research Program for four missions (4 months to one year), with principal researchers from U. of Hawai'i Manoa and Cornell University
The Mission IV crew includes a crew commander (also an expert on food production), an architect, engineer, physicist, astrobiologist, and physician/crew journalist.
The HI-SEAS.org website has a wealth of information and very entertaining and informative crew blogs.

HI-SEAS HABITAT ON MAUNA LOA

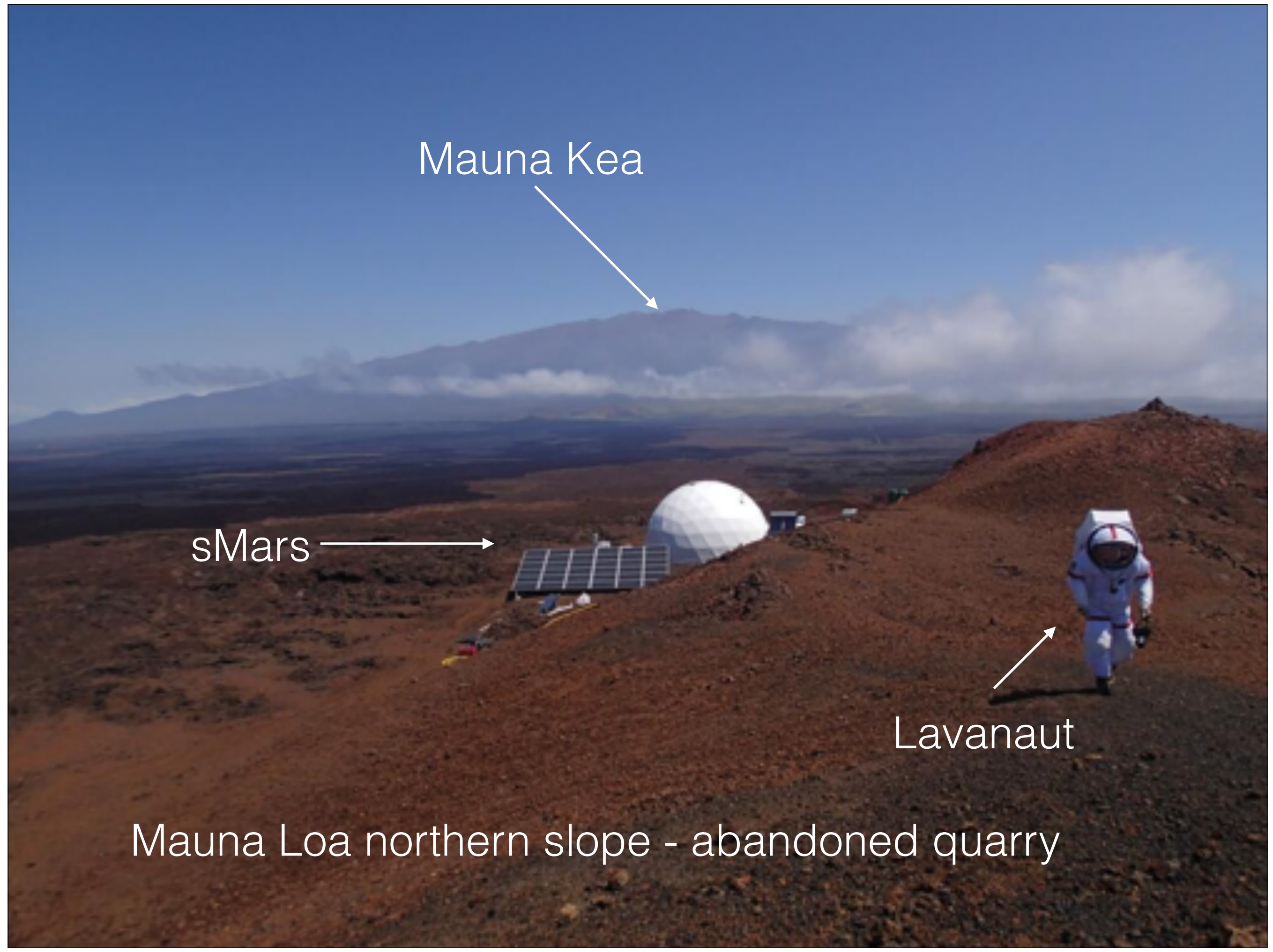


8200 feet, abandoned quarry site, and really does look like the surface of Mars

Basic Mission IV question: “What is required to keep a space flight crew happy and healthy during an extended mission to Mars and while living on Mars?”
Research into food, crew dynamics, behaviors, roles and performance, and other aspects of space flight, and a mission on Mars itself is the primary focus. The HI-SEAS researchers also carry out studies on a variety of other topics as part of their daily activities.



It’s a small space for 6 lavanauts to spend an entire year!



With only a couple tiny windows in the hab, an EVA is really required in order to appreciate the magnificent views . . .


"Airlock" and Workshop in 20-foot steel shipping container
Envision Design, LLC
HI-SEAS

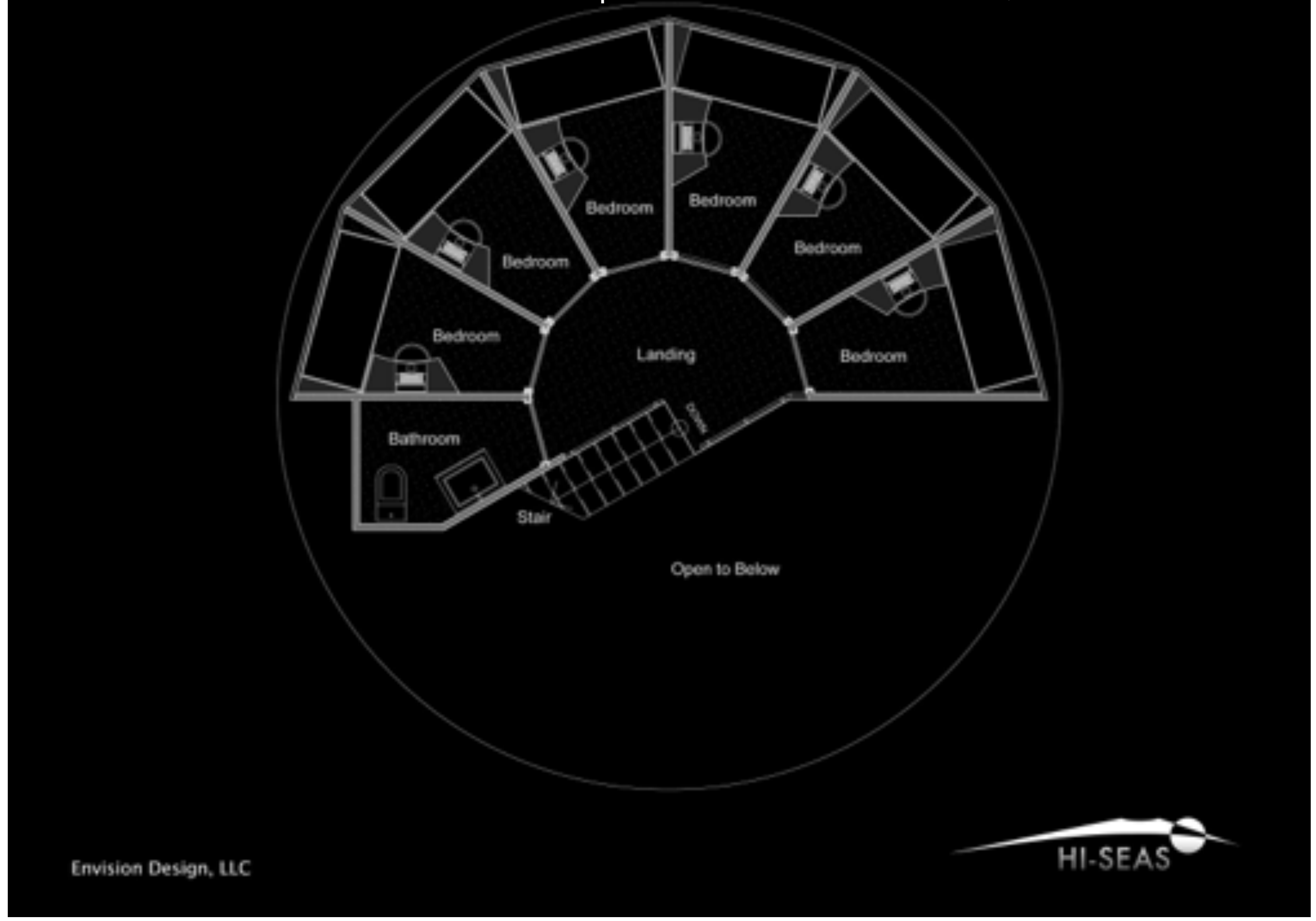
“We live in a dome that has 878 sq ft of usable space, and with six residents that puts us at roughly twice the population density of Mumbai, India” — Carmel Johnson, HI-SEAS IV Crew Commander

Envision Design, LLC


Ground Floor includes common areas such as kitchen, dining, bathroom with shower, lab, exercise, and work spaces
Copyright Sheyna Gifford 2015

Most of the food they consume is dehydrated, and must be rehydrated, but there is fresh produce grown inside the hab.

Second Floor has six separate "staterooms", half bath



An interior shot of four of the staterooms, with a bed, small dresser, table and chair.

DR. SHEYNA GIFFORD, HEALTH & SAFETY OFFICER, MISSION IV

- Main research project involves medical procedure training of a layperson crew (see poster)
- Secondary projects: stress relief for the crew provided by activities like Mars Games, studying the microbiology of the crew over time, and investigating the physiologic response to VR

Sheyna's initial project was to be using a 3-D carbon fiber printer to make necessary medical instruments, but this had to be delayed because the PI had a family emergency. The project should be resuming soon (February).

Practicing a drill to happen later during an EVA

Please see the poster for further information on the medical training of a lay person crew.

[redacted]

Isulio hopes to see you
on Wednesday for pupu's at the Ranch!

Since most of you are from the Hawkeye State I just had to throw this slide in . . .