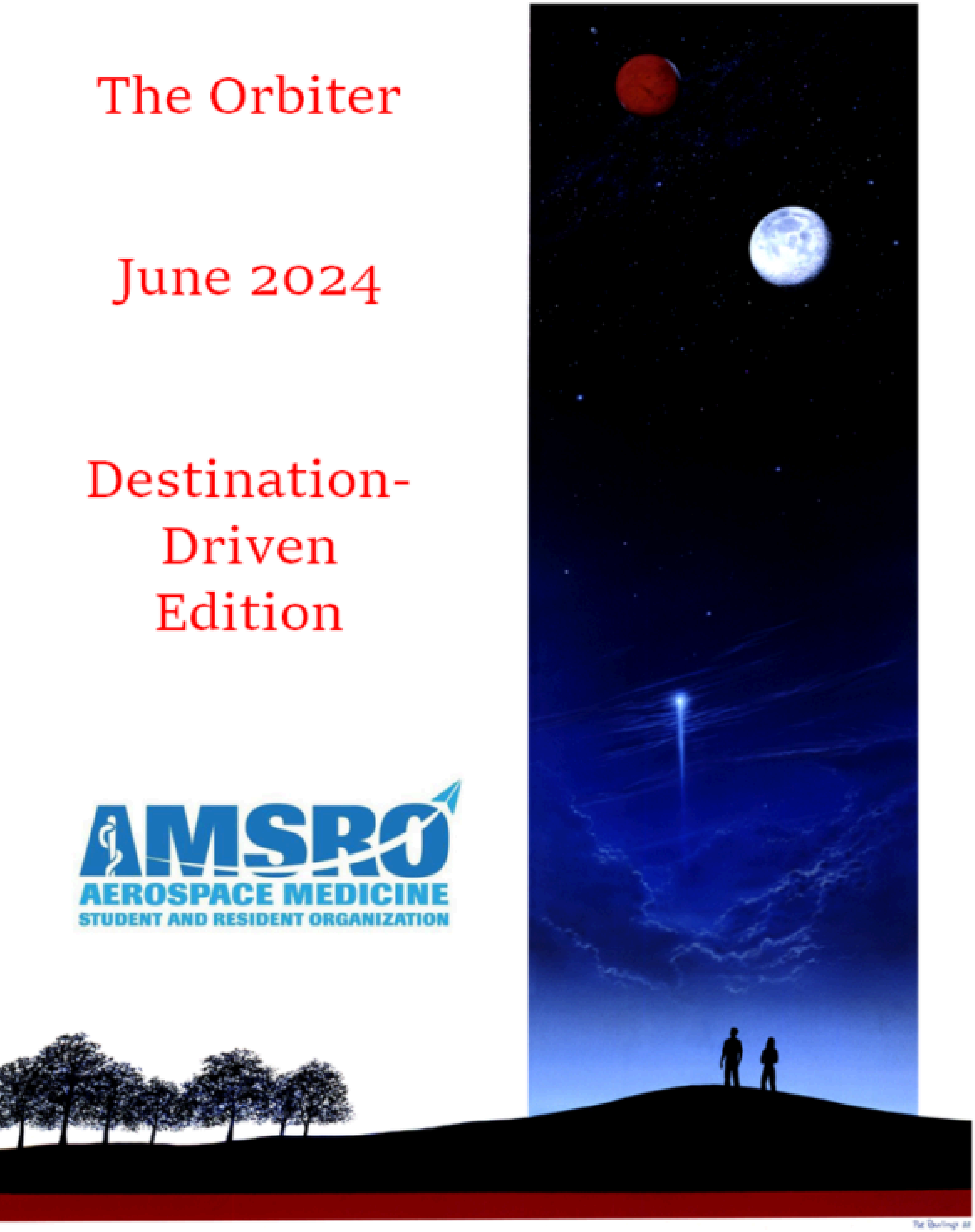
The Orbiter

June 2024

Destination-Driven Edition

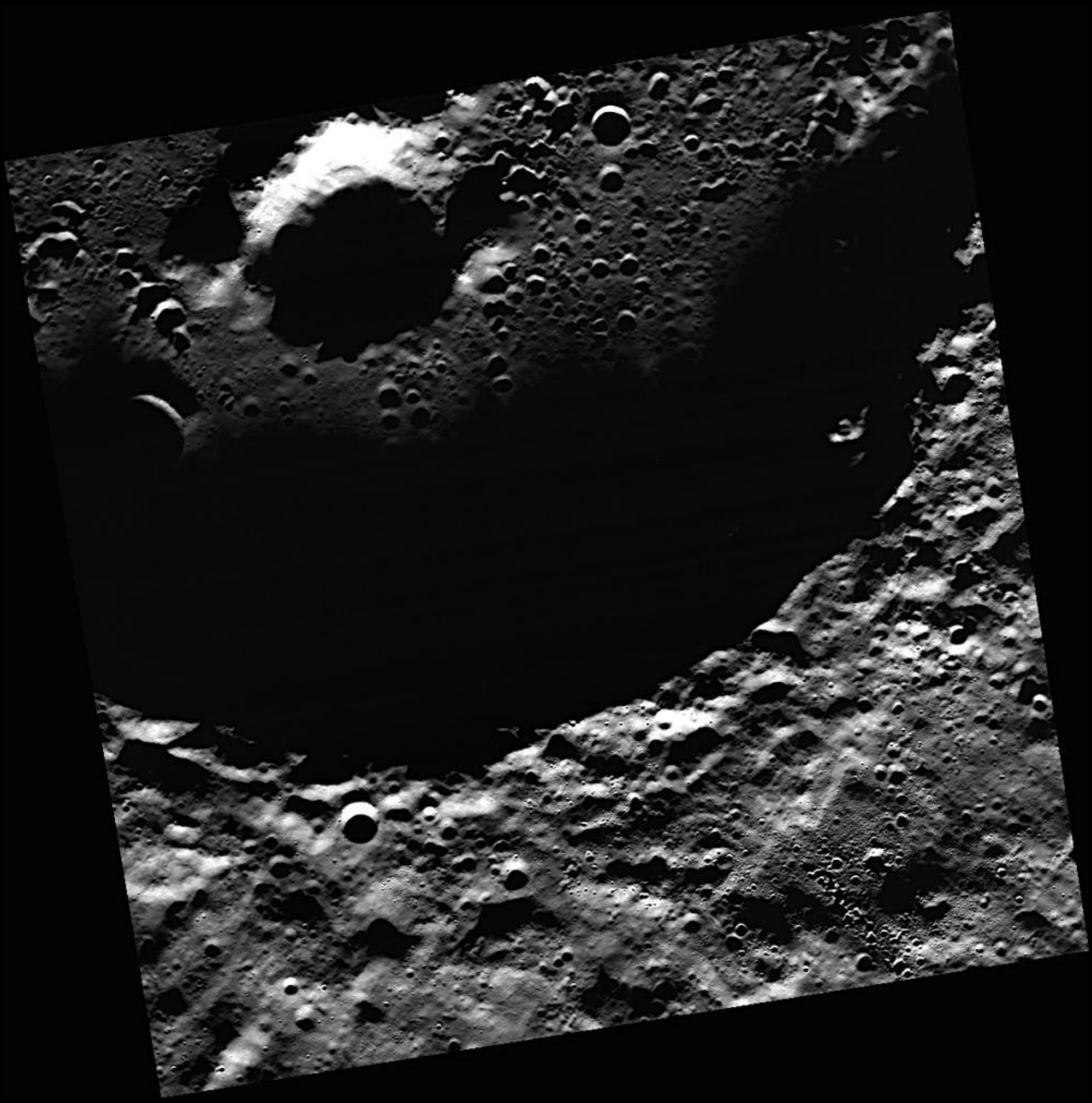
AMSRO
AEROSPACE MEDICINE
STUDENT AND RESIDENT ORGANIZATION



NASA Artwork by Pat Rawlings

Table of Contents

Prokofiev Crater
Mercury



“Prokofiev, named in August 2012 for the Russian composer, is the largest crater in Mercury's north polar region to host radar-bright material. MESSENGER has found evidence that within the cold, dark, permanently shadowed regions of Prokofiev, water ice is exposed on the surface.”
Read more: https://photojournal.jpl.nasa.gov/catalog/PIA16857

Outgoing Chief Editor's Message

In 2023 I ran unopposed for the Chief Editor role. At the time I had been endorsed by both of the now defunct University of Colorado chapters to run for a seat on the AMSRO Executive Committee. My purpose was to advance a message on behalf of the University of Colorado, where I had studied as a graduate student for nine years after concluding my medical school clinical rotations.

The message that led to dual-endorsements was this: the future of the space program is to send humans to other worlds and build bases there. That message resonated strongly with the students of Colorado, and I daresay with many other students across the land.

The point, purpose, and meaning of the space program is not merely to send humans to float around in space and conduct experiments. It is to fly from point A to point B, point B being the surfaces of other worlds. The point of human space exploration is to arrange all of our focus upon sending humans to celestial destinations, exploring them, and harnessing their resources.

In that spirit, it is my honor as the outgoing Chief Editor to hereby name this issue of the Orbiter as the Destination-Driven Edition. It contains articles from the membership as well as information about interesting locations within the solar system.

Sincerely,
Joseph S. Butterfield, MD, MS, MPH, EMT-P
Physician Associate Student, Year 2, University of Pittsburgh Hybrid Program
AMSRO Chief Editor (2023-2024)

The Marius Hills Skylight

Earth's Moon

"The LROC NAC acquired an oblique view of the Marius Hills pit with just the right angle to reveal an overhang. Pit is about 65 meters in diameter, M137929856R. In this geometry, the NAC was able to image a few meters under the overhang discovering a sublunarean void! Will astronauts someday explore under the mare? What scientific riches wait to be discovered within the unseen reaches of sublunarean voids? Also note how the oblique angle really brings out the layered nature of the mare bedrock in the pit walls. These exposed layers give scientists important clues as to how the vast mare were deposited." https://photojournal.jpl.nasa.gov/catalog/PIA14004

Incoming President's Message

Dear AMSRO,

It is my privilege to address this organization with the President's annual message. Over the last year we made several important changes to the organization. Recognizing the need for the AMSRO President to properly learn the role, as well as acknowledging the stability that flows from leadership continuity, we retired the position of Vice-President for the more practical role of President-elect. This change will enable all future Presidents an entire year to become acquainted with the responsibilities of the role, as well as increasing efficiency by removing the need for that person to go through the election process twice. This leadership structure parallels how other AsMA organizations have successfully conducted business.

We also made important changes to the membership of the Executive Committee, including adding the role of Military representative, fully incorporating the RAM representative to voting status, and retiring the immediate past president from the committee. While we appreciate the corporate knowledge and experience of the past president, and while we will continue to consider that person as an important advisor, we think that one needs to be an active participant in order to make decisions for the organization.

The chapter system has been reorganized into a single chapters committee that oversees seven regional chapters established through the US, one in Canada, one in Europe, one in Oceania, and one in South/Central America. To date, these regional chapters host no fewer than eighteen AMSRO affiliated interest groups.

Our organization has shown impressive 13% growth, increasing from 277 to 314 over the past year. I am encouraged by the strong interest shown in this field. Our big tent philosophy has drawn students and residents from a variety of medical, nursing, and related fields throughout the world.

In the year to come, I encourage you to consider getting further involved. We have openings in all of our committees, including Outstanding Mentorship, Scientific Paper Award, Diversity, Anita Mantri PhD Memorial Award, and International Outreach. You can also consider writing an article for the Orbiter. If you'd like to learn more about aerospace medicine feel free to contact senior members of AMSRO. We'd be happy to direct you to learning resources. Finally, if you can think of other ways you'd like to participate, don't hesitate to reach out. We'd like to hear from you.

I wish you success with your academic and professional careers over the next year. As students and residents, our job is to learn. I encourage you to learn all that you can, not only for your own growth, but also for becoming a credit to your patients and to the advancement of science. Aerospace medicine is a great field that demands the best of us. As AMSRO President, it is my goal to help you advance along that path of acquiring knowledge. My very best wishes to you. I hope for a great year for everyone.

Sincerely,
Michael Stephens, MD
Aerospace Medicine Fellow, Mayo Clinic Rochester
AMSRO President

The Bright Spots
Ceres

“A cluster of mysterious bright spots on dwarf planet Ceres can be seen in this image, taken by NASA's Dawn spacecraft from an altitude of 2,700 miles (4,400 kilometers). The image, with a resolution of 1,400 feet (410 meters) per pixel, was taken on June 9, 2015.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA19579

Barriers to the Treatment of Depression in Pilots

Cole Ettingoff, MPH, Trinity School of Medicine
Kristy Jones, Mercer University School of Medicine

It is not uncommon to see pilots or student pilots making jokes on social media about how they're not allowed to feel sad. The reality is that all of them depend upon an active medical certificate to continue their career and a diagnosis such as depression can pose a legitimate threat to their livelihoods.

Imagine for a moment you are a pilot and you are feeling the symptoms of depression. There are effective medications out there but taking them may well end your flying career. Perhaps you feel the pressure to just push through and continue to fly, even when there is a real risk that your depression hinders your ability to be the safest pilot you can be.

The good news is that the FAA recognizes the reality that depression is a medical condition and that untreated depression can pose a significant hazard not only to the pilot themselves but perhaps to their passengers. In many ways this progression mirrors the relationship that our society has with depression in general. A generation ago it was all too often the norm not to talk about depression and not to seek treatment, but the FAA has made these same transition many communities have made in embracing the hope that depression treatment can offer.

Recent FAA guidelines [1] do allow for medical certification of airmen whose depression is treated and while that is a commendable step forward, there are remaining challenges in the protocol that continue to hinder the safety of our pilots and the flying public.

Rather than an immediate denial, use of antidepressants starts a conversation. Unfortunately, the first question in that conversation is if the airman wants to continue their antidepressants. The very question should give a clinician reservations. The question offers airmen two options: discontinue the medication and wait 60 days before reapplying or continue the medication and apply for a medical certificate once they have been on the same dosage for at least 6 months. Perhaps that does not pose a problem for a new applicant who has been on a medication for some time, but for an existing pilot, it means starting antidepressants would require at a bare minimum, six months out of work thus effectively continuing the prohibition on antidepressants for any working pilot.

Beyond the time restrictions, only certain antidepressants are permissible including some but not all SSRIs, bupropion ER and SR, and most recently some SNRIs. The addition of SNRIs is a commendable step forward towards medical certification guidelines which are more compatible with the established standard of care and gives hope that the FAA will continue to review its requirements in light of growing evidence for the treatability of depression.

The FAA has additional requirements with varying degrees of restrictiveness. For instance, the concurrent use of more than one antidepressant is not allowed despite considerable evidence regarding the effectiveness of such practices [2]. That restriction applies not only to current treatment but any history of multidrug treatment for depression.

The FAA also outlines several other disqualifying conditions including psychosis, suicidal ideation, and treatment with electro convulsive therapy. Similarly, these prohibitions are not only on current status but any prior history. We again implore you to consider the implications of these prohibitions. The FAA says in no equivable terms that a pilot who so much as acknowledges that they now have or ever have had the thought of ending their life will never fly again. Such a statement flies in the face of the countless success stories of depression that is effectively treated. Such a stance is painfully out of date, inconsistent with the science, and above all more dangerous than it is protective.

It would be ill advised to think that there are no pilots flying today with thoughts of suicide. One study [3] found the portion of pilots with suicidal thoughts to exceed four percent. That translates to thousands of US pilots suffering in silence and a notable risk to the public.

Cultural barriers to the treatment of depression are changing. It remains all too difficult for many, particularly men, to seek help. That barrier is only amplified by restrictions which prevent access to life changing medications.

References

[1] Guide for Aviation Medical Examiners | Federal Aviation Administration. www.faa.gov. https://www.faa.gov/ame_guide/app_process/exam_tech/item47/amd/antidepressants

[2] SI T, WANG P. When is antidepressant polypharmacy appropriate in the treatment of depression? Shanghai Archives of Psychiatry. 2014;26(6):357-359. doi:https://doi.org/10.11919/j.issn.1002-0829.214152

[3] Wu AC, Donnelly-McLay D, Weisskopf MG, McNeely E, Betancourt TS, Allen JG. Airplane pilot mental health and suicidal thoughts: a cross-sectional descriptive study via anonymous web-based survey. Environmental Health. 2016;15(1). doi:https://doi.org/10.1186/s12940-016-0200-6

Wall of Gale Crater

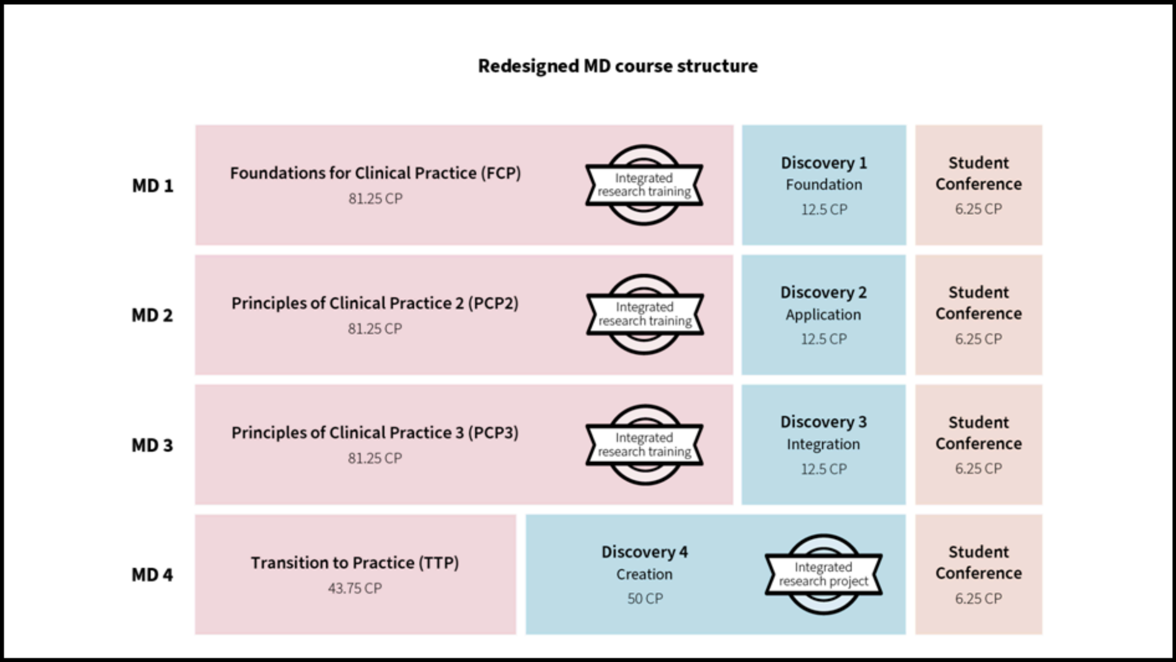
Mars

“This color image from NASA's Curiosity rover shows part of the wall of Gale Crater, the location on Mars where the rover landed on Aug. 5, 2012 PDT (Aug. 6, 2012 EDT). This is part of a larger, high-resolution color mosaic made from images obtained by Curiosity's Mast Camera. This image of the crater wall is north of the landing site, or behind the rover. Here, a network of valleys believed to have formed by water erosion enters Gale Crater from the outside. This is the first view scientists have had of a fluvial system -- one relating to a river or stream -- from the surface of Mars.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA16052

Space health for medical students takes off in Melbourne, Australia

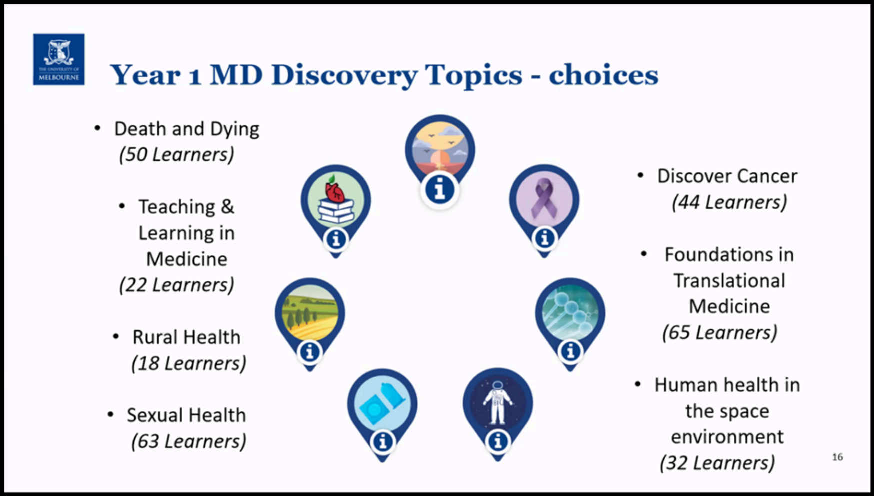
Dr Rowena Christiansen, MBBS, MEmergHlth, MBA, BAHons, LLB, FAsMA, FAsHFA

The University of Melbourne MD course went through a restructure in 2021 to make it more modular and accessible. From 2022 a 'Discovery Subject' stream has been running alongside the core subjects and clinical school placements, and will over time weave through the entire four years of the MD program.

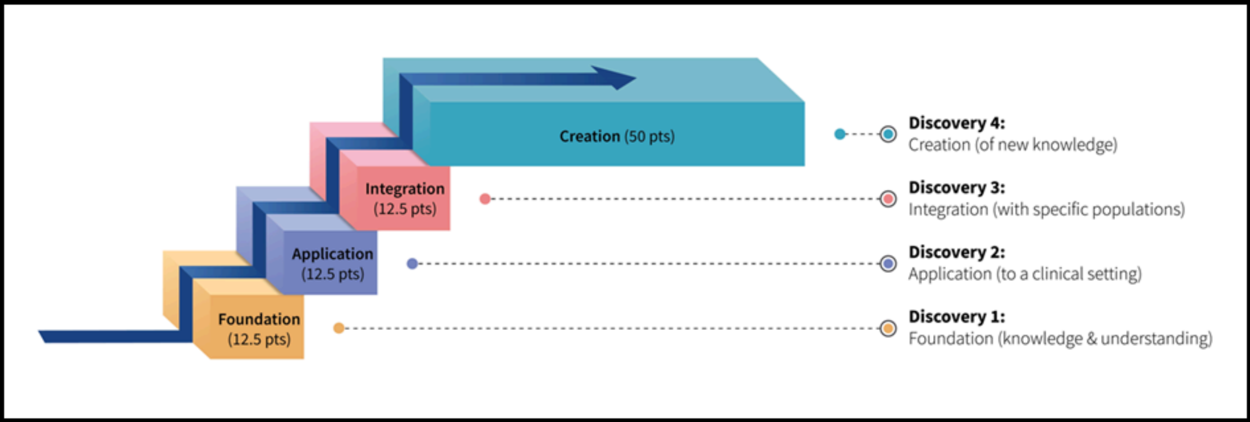


A new MD1 'Discovery Subject' "*Human Health in the Space Environment*" (12.5 points/100) was chosen as one of the seven 'flagship' topics. This was developed by Dr Rowena Christiansen, and launched in early March 2022. By the end of 2024, around 80 medical students will have gained a foundational understanding of human physiology in space. The new course has received very positive feedback, and it is hoped to continue this initiative into a pathway in space health.

During the 24-weeks of the course, MD1 students cover the following blocks in parallel with the human physiology aspect of their core biomedical science subject:



Foundation (space as an extreme environment, and the history of human spaceflight), *Cardiovascular, Respiratory, Gastrointestinal, Metabolism and Immunity,Musculoskeletal/Renal, Neuroscience,* and *Reproduction*. The course materials rely heavily on websites, videos, textbooks, and journal articles offered up by international space agencies and experts. At least one live virtual one-hour 'Meet an Expert' session has been scheduled for each block, and the LEGO "*Build to Launch*" (Artemis I) program has been incorporated so that the students can learn about the teamwork and collaboration essential for successful space missions.



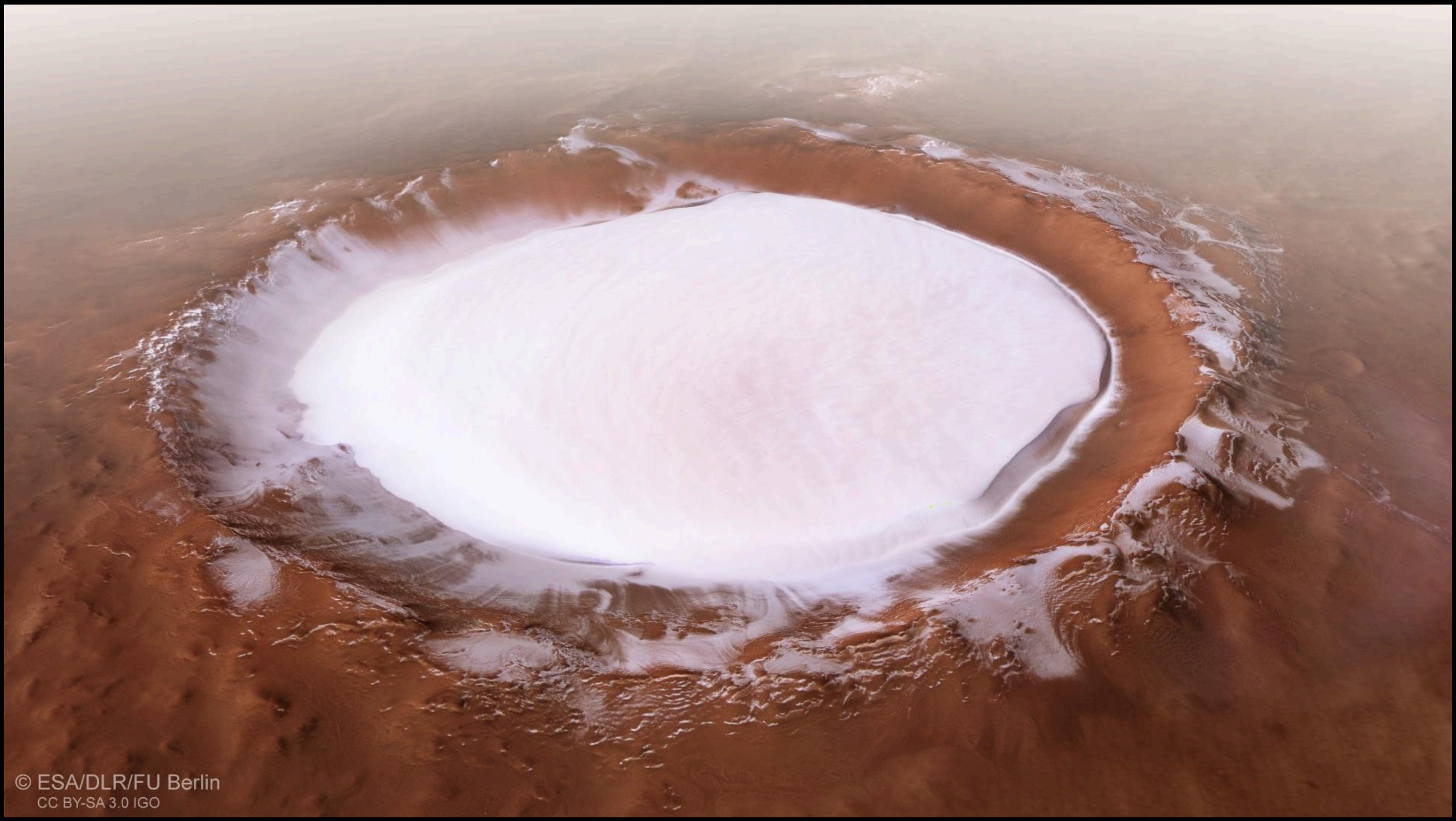
The assessment tasks are designed to build the skills of the students in science communication, and include a group video presentation, a written article to introduce 'space health' to a general audience, and a final individual presentation on 'spinoffs' to demonstrate the translational power of space research for health on Earth.

In 2022, Dr Christiansen has also created a four-week module on ‘humans in space’ for the new Swinburne University of Technology “*Space and Microgravity Science*” subject. This module covers space as an extreme environment, the history of human spaceflight, the key hazards of human spaceflight, and preparing to live on the Moon and Mars.

Dr Rowena Christiansen is the recipient of the 2024 AMSRO Outstanding Mentorship Award

Perspective View of Korolev Crater

Mars



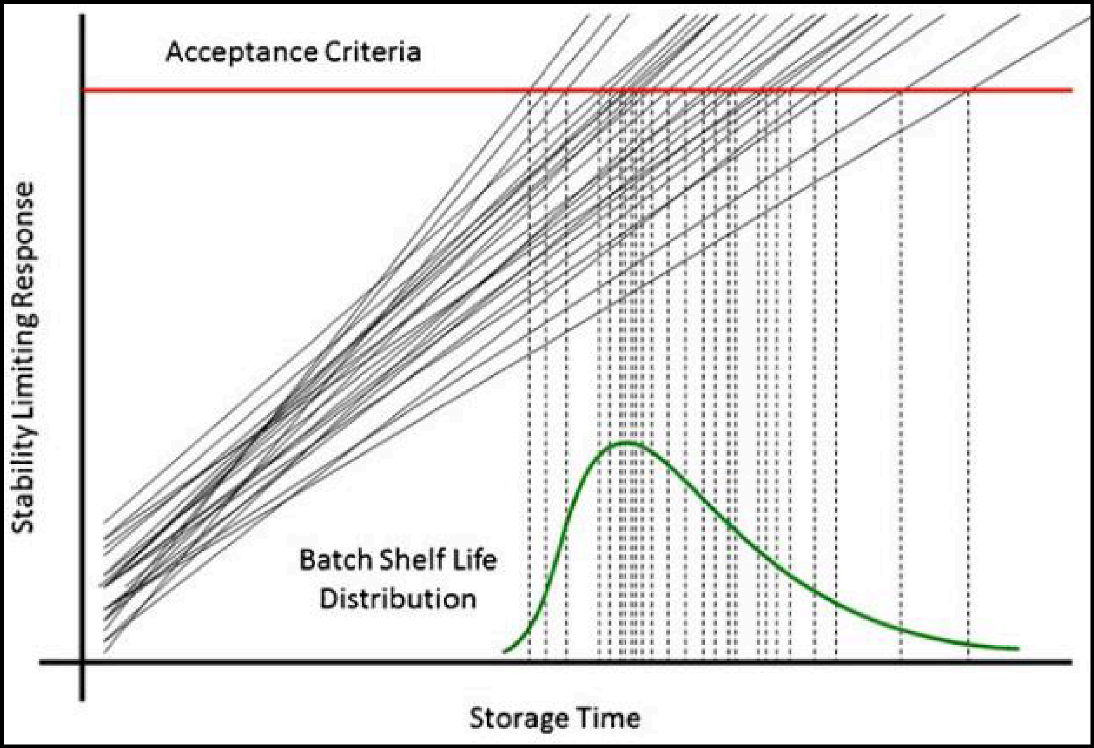
"This image from ESA's Mars Express shows Korolev crater, an 82-kilometre-across feature found in the northern lowlands of Mars. This oblique perspective view was generated using a digital terrain model and Mars Express data gathered over orbits 18042 (captured on 4 April 2018), 5726, 5692, 5654, and 1412. The crater itself is centred at 165° E, 73° N on the martian surface. The image has a resolution of roughly 21 metres per pixel. This image was created using data from the nadir and colour channels of the High Resolution Stereo Camera (HRSC). The nadir channel is aligned perpendicular to the surface of Mars, as if looking straight down at the surface." Read more: https://www.esa.int/Science_Exploration/Space_Science/Mars_Express/Mars_Express_gets_festive_A_winter_wonderland_on_Mars%20

Medication Stability for Long-Duration Missions to Space

Tom Diaz, Pharm.D.
Sam Buesking, Pharm.D. Candidate (2025)

Humans will be at a greater risk of adverse medical conditions during long-duration deep space missions compared to missions in low earth orbit (LEO) [1]. Pharmaceuticals may be the cornerstone of mitigating these risks, along with other countermeasures. Medications are commonly used aboard the International Space Station (ISS) for the treatment of allergies, pain, congestion, and sleep among others [2]. For a 36-month expedition to and from Mars, there are several limitations to medication use which present provisional challenges to Earth-independent medical operations, such as lack of resupply capability, the absence of emergency evacuation, and the expiration of drug products [3]. It will therefore be important to consider the usefulness of a safe and effective pharmacy onboard future missions.

Terrestrial guidance for medication stability is issued by the International Council of Harmonisation (ICH) [4]. This guidance is adopted by the US Food and Drug Administration (FDA) to ensure the quality and safety of drug substances under a variety of factors, including time [4]. Drug stability testing establishes its storage conditions and helps pharmaceutical companies estimate their drug product's shelf-lives and expiration dates [4]. The ICH reports that a drug's potency must fall within 95% and 105%; any variation may allude to changes in safety or efficacy of the medication, presenting danger to the patient [4]. Drug stability studies provide manufacturers with an *estimated shelf-life* of the active pharmaceutical ingredient (API) [5]. Manufacturers then run linear regressions to identify a *supported shelf-life*, and also multiply the estimated shelf-life by 1.5 to identify a *maximum shelf-life* [5]. The shorter of the supported shelf-life and maximum shelf-life then becomes the drug product's *labeled shelf-life*, which is printed on its label [5]. The labeled shelf-life is used to calculate an expiration date for each batch of manufactured drug product, which is the expiration date you may find on prescription bottles [5]. However, this expiration date is merely the minimum period of time that the drug product will remain stable, assuming it is stored in its sealed packaging under recommended storage conditions [5]. These expiration dates may therefore not reflect a drug's *true shelf-life*, which may be significantly longer.



Capen R et al. *AAPS PharmSciTech.* 2012

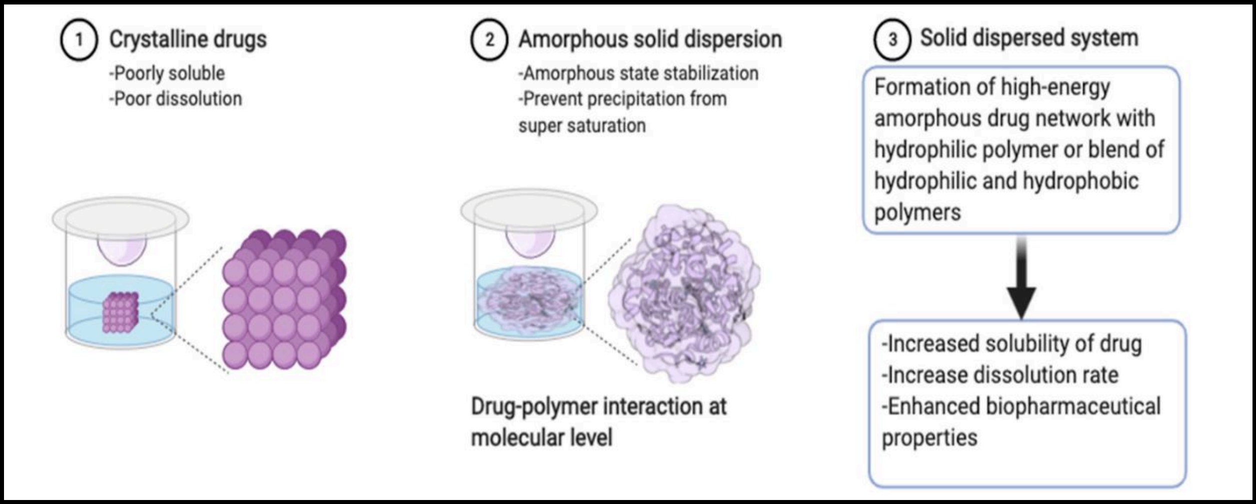
In 1986 the US Department of Defense (DoD) established the Shelf-Life Extension Program (SLEP), a longitudinal effort to implement extensions of the shelf-lives of select lot numbers of pharmaceutical agents based on periodic stability testing by the FDA [6]. This was done to defer replacement costs of certain federal stockpiles for use in public health emergencies, such as an anthrax outbreak. From these studies, it was determined that the API of some drug products maintain their stability years after their labeled shelf-life, such as doxycycline [7]. In addition to these SLEP studies, several similar studies have demonstrated the sustained stability of select drug products years after their labeled shelf-lives [8]. In the context of spaceflight, select contingency medications should be explored for extensions in their shelf-life in order to support earth-independent medical operations for long-duration, deep space missions.

However, it should be recognized that there are several factors in the space environment that may affect the stability of medications during flight. For example, the exact effects of space radiation on medication stability has yet to be fully elucidated [9]. In addition, many of the medications that are routinely stored in the ISS are often repackaged in Ziplock® bags. A recent study suggests that the repackaging of medications prior to flight may be responsible for the accelerated degradation of drug products in space as opposed to radiation [10]. Furthermore, the dosage form of a medication in spaceflight should be considered; evidence suggests that liquid dosage forms may degrade faster than oral dosage forms [9]. Formulary selection and general storage conditions of medications during flight should be scrutinized in years to come for long-duration missions to space.

Taddeo TA et al. *Spaceflight Medical Systems. In: Principles of Clinical Medicine for Space Flight*. 2019.

A potential solution may be portable pharmaceutical manufacturing in space. Dr. Lynn Rothschild, a senior scientist at NASA's Ames Research Center, is heading up several projects through NASA Innovative Advanced Concepts (NIAC), a program that seeks to "change the possible '' in aerospace with ground-breaking technologies and diverse ideas. Rothschild's Phase I and II NIAC Selection initiatives, known as *A Flexible, Personalized, On-Demand Astropharmacy*, feature a pharmaceutical production platform that harnesses the recombinant capacity of *Bacillus subtilis*, a space-hardy, spore-forming bacterium. *B. subtilis* can synthesize drugs when transformed with specialized plasmids [12]. Vallota-Eastman et al. demonstrates how this coding mechanism, when combined with polyhistidine-tags for affinity purification, can successfully produce filgrastim and teriparatide [13]. Filgrastim, a hematopoietic peptide typically indicated for acute radiation syndrome, and teriparatide, a parathyroid hormone analog typically indicated for osteoporosis, could mitigate exposure to microgravity and space radiation. As both of these medications require intensive cold chain infrastructure and can easily be denatured by light or vibration, on-demand production in LEO may be a necessity [14, 15]. Steps are being taken to evaluate the manufacturing capabilities of this *astropharmacy* to produce other medications on the ISS drug formulary [12].

Once an API is manufactured in space, advanced 3D printing techniques like fused deposition modeling (FDM), may produce custom dosage forms for optimized administration. This technique involves the deployment of API-impregnated thermoplastic through a print-head nozzle to form extruded solid dispersions. Solid dispersion products can boost bioavailability and enhance drug dissolution based on API concentration and particular blend of dispersants (provided the API is not denatured by the heat required for printing). Unfortunately, these end-dosage forms may have increased susceptibility to heat and humidity fluctuations, as the print process hinders the formation of crystalline API structures [16]. Additional research is necessary to determine the implications of printing pharmaceuticals in microgravity and the balance between biocompatibility, degradability, and API stability.



Khalid GM, Billa N. *Solid Dispersion Formulations by FDM 3D Printing—A review. Pharmaceutics*. 2022.

Insulin, a peptide-based medication with storage requirements similar to filgrastim and teriparatide, has stability issues that are particularly troublesome on Earth, let alone deep space missions. Dr. Simon Friedman, Curators' Distinguished Professor at the University of Missouri - Kansas City (UMKC), is researching light-controlled release of insulin for advanced integration with continuous glucose monitors (CGMs) and artificial pancreas (AP) technologies. His patented drug delivery method, an injectable photoactivated depot (PAD), employs insulin modified with a non-polar moiety via a light cleaved linker. The result is a stable, highly insoluble material (greater than 90% insulin) that can release active drug when irradiated by light of a specific wavelength. Dr. Friedman has also adapted the PAD method to release glucagon with a different wavelength of light, indicating its extensibility to other thermolabile medications [17]. While the long-term stability of drug PADs have yet to be evaluated, this pharmaceutic methodology warrants continued validation and refinement, having significant potential interoperability with *Astroskin* health monitoring systems [18].

Although there are many factors in the space environment to consider when analyzing the stability of medications commonly used in space, there is a necessity to develop a repository of the terrestrial shelf-lives of these medications. Unfortunately, expiration data in the US is primarily proprietary information. Blue et al. and Diaz et al. explored the terrestrial shelf-lives of common medications on the ISS; the latter pre-print study found that more than half of the medications routinely stored in the ISS medication kits may expire by 36 months based on terrestrial shelf-lives [19, 20]. However, understanding the factors that may impact drug stability in space is crucial, as instability of pharmaceutical agents increases the risk of therapeutic failure and may complicate mission planning. Ultimately, those responsible for the health of astronauts may extrapolate this data and weigh the risk versus benefit of using potentially expired medications for a long-duration mission.

References

[1] Goldin DS. (1999, Oct 25). Planning an Infrastructure for Astronaut Health Care [Speech]. US National Academy of Sciences, Washington (DC). As Published in Safe Passage: Astronaut Care for Exploration Missions. 2001.

[2] Wotring VE. Medication use by U.S. crewmembers on the International Space Station. FASEB J. 2015; 29(11): 4417-23. doi: 10.1096/fj.14-264838.

[3] Tran QD, Tran V, Toh LS, et al. Space Medicines for Space Health. ACS Med Chem Lett. 2022;13(8):1231-1247. doi:10.1021/acsmedchemlett.1c00681

[4] U.S. Food and Drug Administration (FDA). Q1A(R2) Stability Testing of New Drug Substances and Products. U.S. Department of Health and Human Services. 2003. https://www.fda.gov/media/71707/download.

[5] Capen R, Christopher D, Forenzo P, et al. On the Shelf Life of Pharmaceutical Products. AAPS PharmSciTech. 2012; 13(3): 911-918. Doi: 10.1208/s12249-012-9815-2.

a.Picture 1

[6] Expiration Dating Extension. U.S. Food and Drug Administration (FDA). 2024. https://www.fda.gov/emergency-preparedness-and-response/mcm-legal-regulatory-and-policy-framework/expiration-dating-extension.

[7] Bumpus NN. Update on Expiration Date Extensions of Certain Lots of Doxycycline Hyclate 100mg Capsules Held in Strategic Stockpiles. U.S. Food and Drug Administration (FDA). 2023. https://www.fda.gov/media/165311/download

[8] Lyon, R., Taylor, J., Porter, D., Prasanna, H. & Hussain, A. Stability profiles of drug products extended beyond labeled expiration dates. J Pharm. Sciences. 2006; 96: 1549–1560. Doi: 10.1002/jps.20636

[9] Blue RS, Chancellor JC, Antonsen EL, et al. Limitations in predicting radiation induced pharmaceutical instability during long-duration spaceflight. npj Microgravity. 2019; 5(1): 15. Doi: 10.1038/s41526-019-0076-1.

[10] Reichard JF, Phelps SE, Lehnhardt KR, et al. The effect of long-term spaceflight on drug potency and the risk of medication failure. npj microgravity. 2023; 9: 35. Doi: 10.1038/s41526-023-00271-6.

[11] Taddeo, T.A., Gilmore, S., Armstrong, C.W. (2019). Spaceflight Medical Systems. In: Barratt, M., Baker, E., Pool, S. (eds) Principles of Clinical Medicine for Space Flight. Springer, New York, NY. https://doi.org/10.1007/978-1-4939-9889-0_6.

a. Picture 2

[12] Hall L. A Flexible, Personalized, On-Demand Astropharmacy. Published April 6, 2023. Accessed May 4, 2024. https://www.nasa.gov/general/a-flexible-personalized-on-demand-astropharmacy/

[13] Vallota-Eastman A, Bui C, Williams PM, Valentine DL, Loftus D, Rothschild L. Bacillus subtilis engineered for aerospace medicine: a platform for on-demand production of pharmaceutical peptides. Frontiers in Space Technologies. 2023;4. doi:https://doi.org/10.3389/frspt.2023.1181843

[14] Filgrastim. In: Lexi-Drugs. UpToDate Lexidrug. Updated May 03, 2024. Accessed May 4, 2024. http://online.lexi.com

[15] Teriparatide. In: Lexi-Drugs. UpToDate Lexidrug. Updated April 19, 2024. Accessed May 4, 2024. http://online.lexi.com

[16] Khalid GM, Billa N. Solid Dispersion Formulations by FDM 3D Printing—A review. Pharmaceutics. 2022;14(4):690. doi:10.3390/pharmaceutics14040690

a. Picture 3

[17] Friedman SH. Replacing Pumps with Light Controlled Insulin Delivery. Current Diabetes Report. 2019;19(11). doi:10.1007/s11892-019-1233-3

[18] Kumar A, Levin E, Cowings P, Toscano W. Evaluation of the accuracy of Astroskin as a Behavioral Health Self-Monitoring System for Spaceflight. Accessed May 15, 2024. https://ntrs.nasa.gov/api/citations/20150021842/downloads/20150021842.pdf

[19] Blue RS, Bayuse TM, Daniels VR, et al. Supplying a pharmacy for NASA exploration spaceflight: challenges and current understanding. npj microgravity. 2019; 5(14). Doi: 10.1038/s41526-019-0075-2.

[20] Diaz TE, Ives EC, Lazare DI, et al. Expiration Analysis of the International Space Station Formulary for Exploration Mission Planning. npj microgravity. 2023. Doi: 10.21203/rs.3.rs-3315046/v1. [PREPRINT]

Victoria Crater at Meridiani Planum Mars

"Victoria Crater," about 800 meters (one-half mile) in diameter, has been home ground for NASA's Mars Exploration Rover Opportunity for more [than] 14 of the rover's first 46 months on Mars." Read more: https://photojournal.jpl.nasa.gov/catalog/PIA08813

Gravity, or the Lack Thereof...

Dr Rowena Christiansen, MBBS, MEmergHlth, MBA, BAHons, LLB, FAsMA, FAsHFA

Gravity is a fundamental force of nature that plays a crucial role in shaping the conditions necessary for life on Earth. Without gravity, life as we know it would be impossible, as it affects a wide range of biological, physical, and environmental factors. In this article, we will explore why gravity is important for life on Earth and what happens in microgravity environments, such as those experienced by astronauts in space.

Gravity's Influence on Life on Earth:

1. Biological Effects:

Gravity is vital for the development and maintenance of life on Earth. Organisms have evolved over millions of years to adapt to Earth's gravitational force. Plants use gravity to grow their roots downward and their stems upward. Animals and humans rely on gravity to maintain proper bone density, muscle strength, and cardiovascular (heart and circulatory system) health.

2. Atmospheric Retention:

Gravity is responsible for retaining the Earth's atmosphere. The gravitational pull keeps the Earth's atmosphere close to the surface, preventing it from being lost into space. This is essential for maintaining the optimal conditions necessary for life, as the atmosphere provides oxygen for breathing, regulates temperature, and protects against harmful cosmic (space) radiation.

3. Climate Regulation and the Water Cycle:

Gravity also plays a role in climate regulation. It influences the circulation of air and ocean currents, which in turn affect weather patterns and temperature distribution on Earth. Gravity is also essential for the water cycle, as it allows water to flow from higher elevations to lower ones. This movement of water, driven by gravity, is essential for maintaining the distribution of freshwater resources and supporting ecosystems and agriculture.

What Happens in Microgravity:

Microgravity, or weightlessness, is a condition experienced by astronauts in space, and it results from being in a state of continuous free fall around the Earth. In microgravity, several significant physiological and physical changes occur:

1. Muscle Atrophy:

In the absence of gravity, some muscles are not used as extensively, as they do not need to work against the effects of gravity. This can result in a significant loss of muscle mass and strength, affecting an astronaut's ability to perform physical tasks upon returning to Earth.

2. Bone Loss:

Extended exposure to microgravity causes a decrease in bone density. This weakening of bones can increase the risk of fractures and long-term skeletal problems such as osteoporosis for astronauts.

3. Fluid Redistribution:

In microgravity, bodily fluids shift toward the upper body and head, leading to facial puffiness and increased intracranial pressure (inside the skull). This can affect smell and taste.

4. Cardiovascular Changes:

In the absence of gravity, the cardiovascular system experiences deconditioning (becomes less fit). This can lead to ‘orthostatic intolerance’, where astronauts may have difficulty standing up and returning to normal gravitational conditions upon their return to Earth.Astronauts exercise up to 2.5 hours a day in space as a ‘countermeasure’.

5. Fluid Behaviour:

Fluids behave differently in microgravity. They form spherical shapes, making it challenging for astronauts to drink liquids from open containers. This altered fluid behaviour can also affect the transportation of nutrients and waste products within the body.

In conclusion, gravity is essential for life on Earth, as it influences biological processes, atmospheric retention, climate regulation, and the water cycle. In contrast, microgravity leads to a range of physiological changes that pose challenges for astronauts in space. Understanding the importance of gravity on Earth and its effects in microgravity is critical for space exploration and the development of countermeasures to mitigate the health risks associated with long-duration space missions.

Europa

Jupiter System

“The puzzling, fascinating surface of Jupiter's icy moon Europa looms large in this newly-reprocessed color view, made from images taken by NASA's Galileo spacecraft in the late 1990s. This is the color view of Europa from Galileo that shows the largest portion of the moon's surface at the highest resolution. The view was previously released as a mosaic with lower resolution and strongly enhanced color (see PIA02590). To create this new version, the images were assembled into a realistic color view of the surface that approximates how Europa would appear to the human eye.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA19048

Barotrauma in the ER: Approach to Assessment and Treatment of Acute Onset Ear Pain After a Flight

Christina Krupinski and Cole Ettingoff, MPH
Trinity School of Medicine

A 35-year-old male presents to the emergency room with a chief complaint of ear pain. The pain started abruptly around one hour ago during the final stage of an international flight. The patient reports he was previously healthy but now finds the pain to be excruciating.

Approach to Assessment

While ear pain after a flight is a relatively common occurrence, nontraumatic ear pain is an uncommon presenting complaint in most Emergency Departments (EDs). Therefore, many EM physicians understandably have limited experience in otoscopic examinations. However, the approach to nonspecific ear pain is relatively similar to the approach a clinician might use to evaluate other nontraumatic pain of the face. One direct way to approach the evaluation of nonspecific sudden onset ear pain is a three-part strategy: context, localization, and otoscopic exam.

1) Context: As with most examinations, a thorough history is critical. In instances of acute pain, physicians are often able to identify a clear precipitating incident, as is the case with the above-mentioned patient who has recently traveled a significant distance via plane. Commercial flights are routinely pressurized to the equivalent of atmospheric pressure at 8,000 feet above sea level, making it uncommon to see barotrauma of the ear, yet it remains crucial to be able to recognize the signs and symptoms for a prompt diagnosis. Although unpressurised flights may experience greater variation in pressure, even in cases of emergency descent, they are unlikely to create traumatic injury in the absence of preexisting conditions. While recent history of flying in an airplane may be the major precipitating incident, knowledge of contributing factors can aid in the

diagnosis. Of particular interest, past history of negative experiences with pressure changes, recent infections in the upper respiratory tract or sinuses, and indications of inflammation experienced prior to the flight, such as inflammation secondary to seasonal allergies or exposure to environmental irritants [1]. These factors can give rise to dysfunction of the Eustachian tube, becoming unable to maintain a relatively constant air pressure and potentially leading to barotrauma of the ear.

2) Localization: After gathering a history of present illness and pertinent history, an assessment of the ear should be completed in the following sequence: inspection, palpation, and otoscopic examination. Inspection and palpation of the ears should reveal no significant findings in the case of ear barotrauma [2]. In order to rule out TMJ disorder, palpation of the temporomandibular joint should also be included in palpation [3].

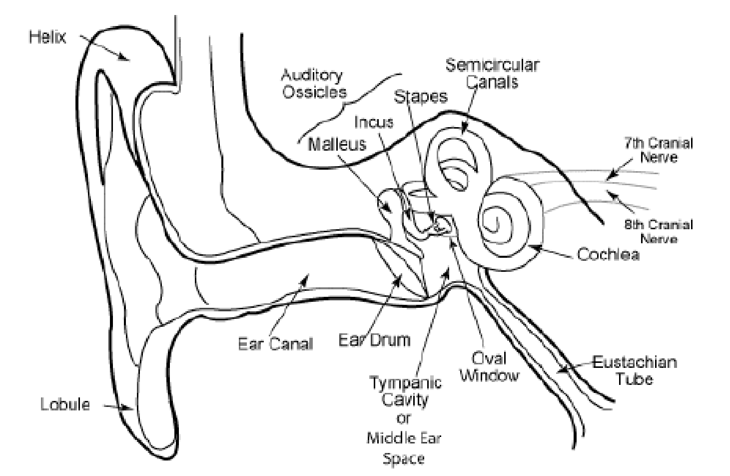


Figure 1: Anatomy of the Ear[6]

It is important to note, if the patient reports a change in hearing or vertigo, additional testing should be considered. For hearing loss, perform a Weber, Rinne, or Whisper test. For vertigo, perform a balance test (Romberg's test) to rule out cerebellar dysfunction.

In the absence of abnormal examination findings, the following tests are recommended: a CT scan to identify any physiological or pathological irregularities of the ear and an MRI to rule out malignancy of the head and neck. Though, it is worth noting both tests may reasonably be deferred to an outpatient follow-up in most circumstances.

Modified TEED classification of middle ear barotrauma

Grade	Findings on otoscopy
0	Normal examination
1	Tympanic membrane injection or retraction
2	Slightly haemorrhagic tympanic membrane
3	Grossly haemorrhagic tympanic membrane
4	Haemotympanum
5	Tympanic membrane perforation

Table 1: TEED Scale[5]

3)Otoscopic exam: While this exam may appear daunting, a basic otoscopic exam in the acute care setting requires limited expertise. Upon insertion of the otoscope into the ear, the tympanic membrane and middle ear should become visible. Note the color of the tympanic membrane, and the presence of inflammation, discharge, or perforation bilaterally. Normally, the tympanic membrane is noted as pearly white and the malleus, incus, and light reflex is visualized as seen in Figure 2. In the case of acute ear barotrauma, hemotympanum is a common finding in the affected ear or ears [1] as seen in Figure 3. Severity should be assessed and documented based on the Modified Teed Classification [4] (see Table 1).

Clinicians should not be concerned to see a synthetic tube implanted in the ear drum (Figure 4). Tympanostomy tubes are commonly used to facilitate the equalization of pressure across the eardrum and can become obstructed, leading to a risk of barotrauma. Thus, reasonable effort should be made during otoscopic examination to confirm proper tube placement through the tympanic membrane and to exclude presence of a foreign object.

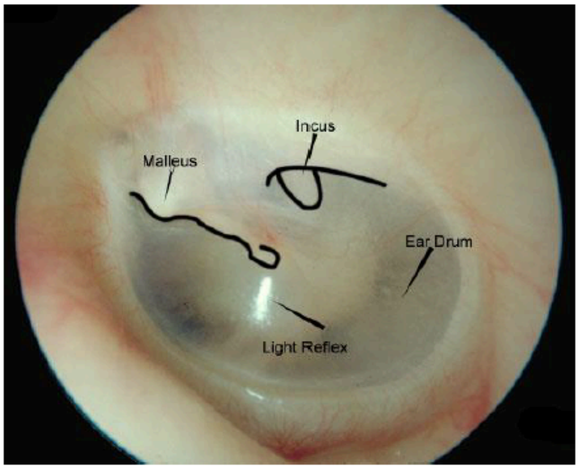


Figure 2: Normal Ear Drug[6]

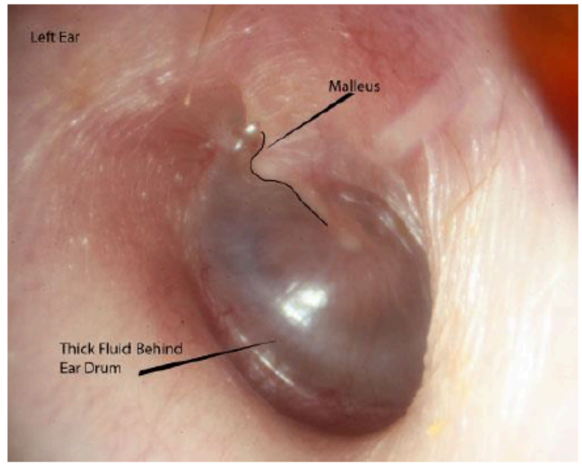


Figure 3: Travelers Ear[6]

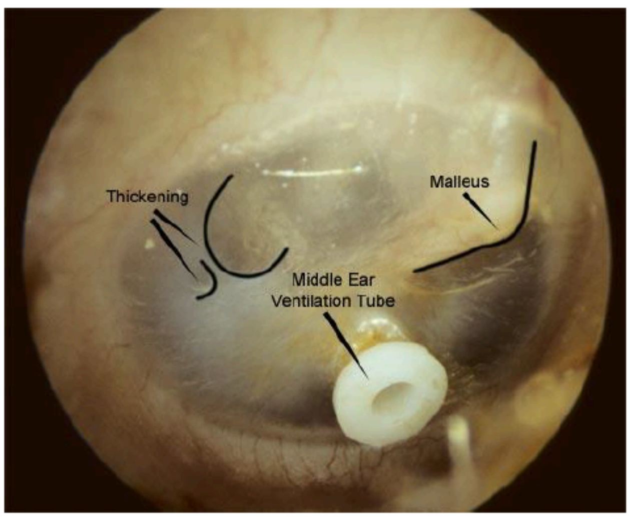


Figure 4: Adult with Tube in Ear[6]

Differential Diagnoses

Barotrauma in the acute care setting is a diagnosis of exclusion. Clinicians should consider the most common causes of generalized ear pain: otitis media, foreign body obstruction, trauma, and TMJ disorder [2].

Otitis media is one of the most common causes of ear pain seen in the ER. Similarly to barotrauma, otitis media may be unilateral or bilateral and may present with a history of upper respiratory tract infection. An erythematous tympanic membrane is likely visualized on otoscopic examination in both otitis media and barotrauma; however, the presence of a fever and collection of pus indicate signs of infection rather than barotrauma. In the case of otitis media, care should be taken to examine for systemic effects including examination of the nasopharynx and oropharynx.

A foreign body causing ear pain is more common in the pediatric population, and the presence of a foreign body can be visualized in the ear canal. In an era where earphones and similar devices are commonplace, foreign bodies in the ear canal are well within reason for patients of all ages.

While trauma to the ear is infrequent, it can be another cause of sudden onset ear pain and should always be suspected when other signs are present, such as battle signs. As seen in the image below, the relative fragility of the eardrum may make seemingly mundane impacts within the ear canal a potential source of traumatic injury. In addition to an otoscopic exam, a CT scan of the head should be considered to ensure injury is localized to the ear [5].

Lastly, TMJ disorder should be suspected when abnormal findings are isolated to pain upon palpation or use of the temporomandibular joint.

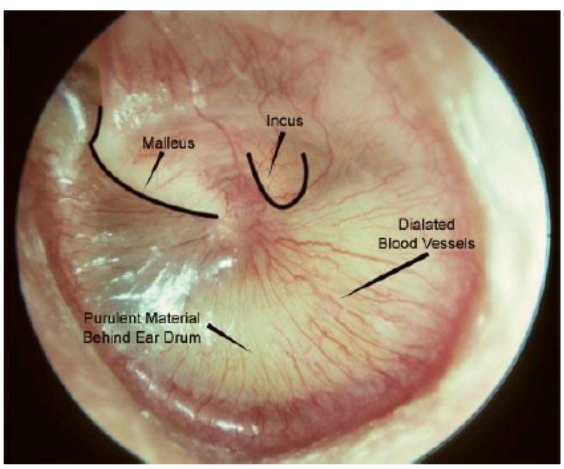


Figure 5: Middle Ear Infection

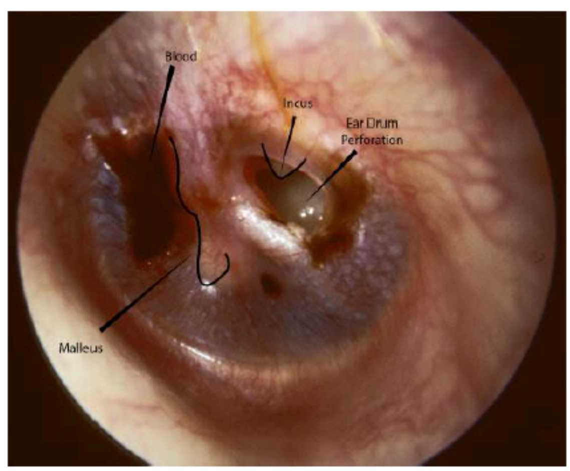


Figure 6: Ear Trauma from Qtip Use[6]

Treatment or Self-Resolution of Ear Barotrauma

Most cases of barotrauma can be treated conservatively with over-the-counter decongestants, perhaps with the addition of an NSAID to provide pain relief and decrease inflammation. Steroids may provide additional benefit as the ear recovers [2]. Patients should be advised to resist the urge to physically manipulate the ear, such as using cotton swabs, so as to avoid additional injury.

Utilizing specialist consultation should be considered in cases involving acute onset rupture of the eardrum or loss of hearing [2]. A follow-up with primary care is advised when the patient has ear pain with underlying concerns or future travel via airlines.

Back to Our Patient

A 35-year-old male presents to the emergency room with a chief complaint of ear pain. The pain started abruptly around one hour ago during the final stage of an international flight. The patient reports he was previously healthy, but he now finds the pain to be excruciating.

On interview, this patient reported only mild environmental allergies and denied history of recent illness or previous ear problems but did note he had spent several days on this trip exploring the local botanical gardens. Examination revealed no hearing loss, deformity, or tenderness to palpation on the exterior ear or jaw, and no other symptoms suggesting systemic problems were involved such as difficulty swallowing or trouble breathing. Otoscopic exam found bilateral inflammation and general irritation of the ear canal with moderate edema behind one ear drum and a small quantity of blood noted behind the other ear, classified as TEED 2.

The presence of the blood prompted a CT scan of the head and consultation with ENT. ENT reported the CT as unremarkable and sent the patient home with a prescription for steroids and scheduled a follow-up visit for the next day.

Upon exam, ENT determined no significant damage had been done to the ear and counseled the patient on strategies for preventing injury on future flights including proactive use of oral antihistamine and an OTC steroid nasal spray.

Upon additional pain on his next flight, the patient complemented these medications with a commercially available pressure filtering ear plug. He even found that the product's corresponding app was capable of using his iPhone's air pressure sensor to advise when the ear plugs should be worn during flight.

References

[1] Westerman T, Fine M, Gilbert L. Aerotitis: Cause, prevention, and treatment. The Journal of the American Osteopathic Association.1990;90(10)926-928. https://doi.org/10.1515/jom-1990-901013

[2] Agzarian A, Agzarian A. Middle Ear Barotrauma (Barotitis Media). Proced. Of UCLA Healthcare. 2013;17 https://www.proceedings.med.ucla.edu/wp-content/uploads/2016/11/Middle-Ear-Barotrauma-edited.pdf

[3] Ely JW, Hansen MR, Clark EC. Diagnosis of ear pain. Am Fam Physician. 2008;77(5):621-628.

[4] Oneill O, Brett K, Frank A (2024) "Middle Ear Barotrauma", in State Pearls. Treasure Island (FL): StatPearls. Available at: https://www.ncbi.nlm.nih.gov/books/NBK499851/#article-31565.s8 (Accessed: 22 April 2024).

[5] Claes J, Germonpre P, Rompaey V, Bourmanne E. Ear, nose and throat and non-acoustic barotrauma. B-ENT. 2016;12(Suppl. 26/1):203-218. https://repository.uantwerpen.be/docman/irua/410a44/139937.pdf

[6] Owens T. Ear Disease Photo Book. McGovern Medical School: Department Of Otorhinolaryngology – Head & Neck Surgery. Accessed April 22, 2024. https://med.uth.edu/orl/online-ear-disease-photo-book/.

The Icy Jets of Enceladus

Saturn System

“With Enceladus nearly in front of the Sun from Cassini's viewpoint, its icy jets become clearly visible against the background. The view here is roughly perpendicular to the direction of the linear "tiger stripe" fractures, or sulci, from which the jets emanate. The jets here provide the extra glow at the bottom of the moon. The general brightness of the sky around the moon is the diffuse glow of Saturn's E ring, which is an end product of the jets' material being spread into a torus, or doughnut shape, around Saturn.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA09761

NASA's Five Hazards of Human Spaceflight and Countermeasures

Dr Rowena Christiansen, MBBS, MEmergHlth, MBA, BAHons, LLB, FAsMA, FAsHFA

Human spaceflight is a remarkable endeavour that pushes the boundaries of scientific knowledge and technological capabilities. However, venturing beyond our planet's atmosphere comes with a unique set of challenges and hazards. NASA, the US space agency, has identified five primary hazards of human spaceflight, each of which poses potential risks to astronauts' health and well-being. These hazards are: 'RIDGE' - radiation, isolation and confinement, distance from Earth, differing gravitational fields, and hostile and closed environments. NASA and its international partners have developed a range of countermeasures to mitigate these hazards and ensure the safety and success of space missions.

1. Space Radiation:

Radiation exposure is a significant concern for astronauts traveling beyond Earth's protective atmosphere. In space, they are exposed to harmful cosmic radiation and solar radiation, which can damage DNA and increase the risk of cancer. To counter this hazard, NASA employs a multi-faceted approach. Astronauts are equipped with dosimeters to measure their exposure, and missions are scheduled during periods of lower solar activity to reduce radiation risk. Spacecraft are also designed with shielding materials to minimize radiation exposure. Additionally, research into advanced shielding technologies and pharmaceutical interventions to mitigate radiation effects is ongoing.

2. Isolation and Confinement:

Space missions often involve long periods of isolation and confinement within a spacecraft or space station. This isolation can lead to psychological stress and interpersonal conflicts among crew members. To address this hazard, NASA has developed extensive crew selection and training programs to help astronauts cope with isolation and confinement. These programs include psychological support, communication training, and conflict resolution techniques. The implementation of recreational activities and designated personal spaces within spacecraft and space stations also contributes to the well-being of the crew.

3. Distance from Earth:

The vast distances between Earth and destinations like the Moon, Mars, or asteroids create significant logistical challenges. In the event of an emergency, the time delay in communications with Mission Control can be life-threatening. NASA employs a range of strategies to mitigate this hazard. Redundant communications systems and autonomous decision-making capabilities are integrated into spacecraft to address communications delays. Extensive pre-mission training and simulation exercises prepare astronauts to handle emergencies independently, reducing their dependence on real-time Earth-based assistance.

4. Hostile and Closed Environments:

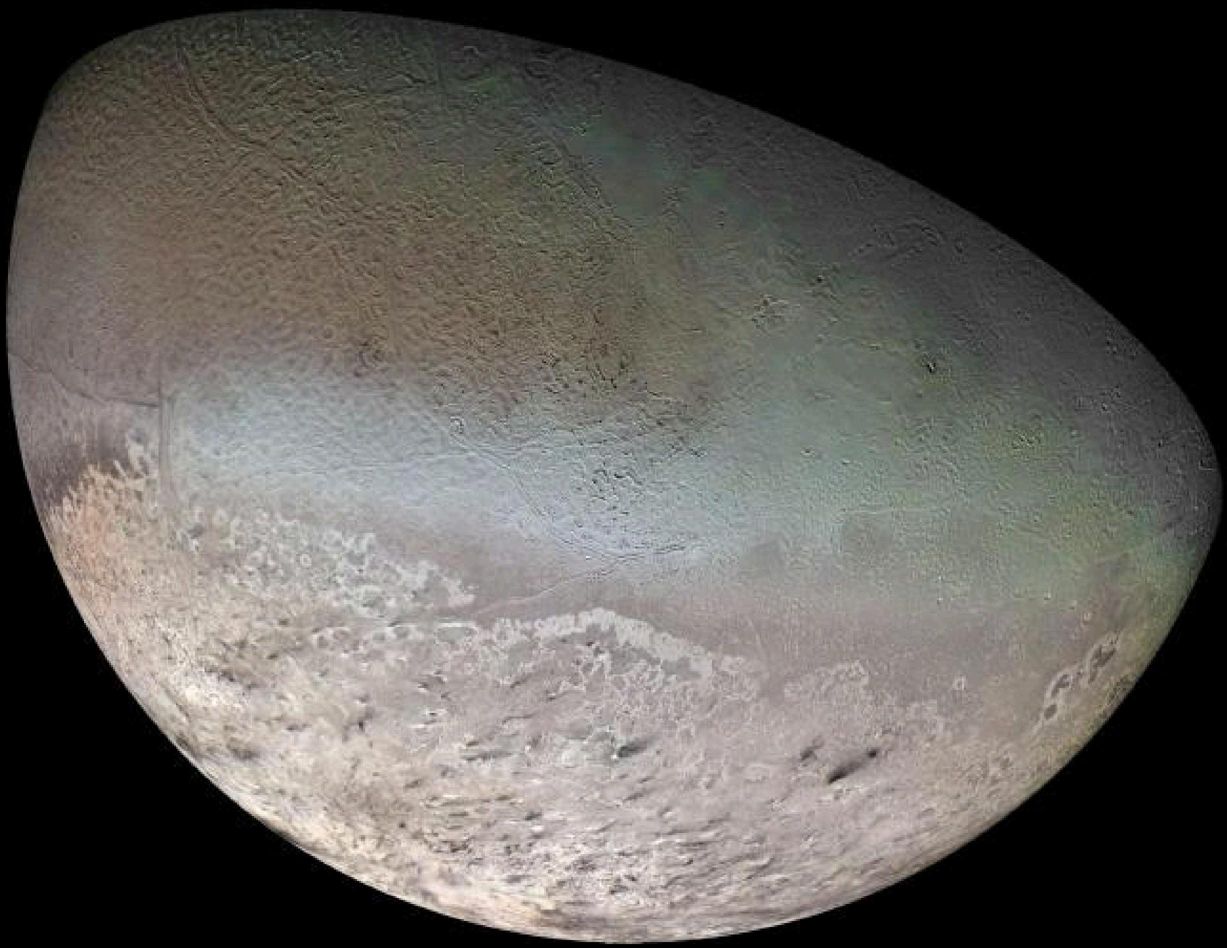
Spacecraft and space stations are closed vessels within the hostile space environment, where life support systems are essential for survival. Any failure of these systems can lead to catastrophic consequences. NASA has implemented strict quality control and testing processes to ensure the reliability of life support systems. Additionally, crew members receive training in maintenance and repair of critical systems. Continuous monitoring of environmental conditions, including air quality, temperature, and pressure, helps to address potential issues before they become life-threatening.

5. Microgravity:

Prolonged exposure to microgravity can lead to various physiological changes, including muscle atrophy (loss of size and strength), bone density loss, and cardiovascular deconditioning (loss of fitness). To counteract these effects, NASA has developed exercise regimens and specialized equipment to help astronauts maintain their physical health. The International Space Station (ISS) is equipped with exercise devices such as treadmills and resistance machines to simulate weight-bearing activities. These countermeasures, along with rigorous monitoring of astronauts' health, have proven effective in mitigating the impact of microgravity.

In conclusion, NASA's five hazards of human spaceflight encompass a range of challenges that must be addressed to ensure the safety and success of missions beyond Earth. Through a combination of advanced technology, rigorous training, and ongoing research, NASA has developed effective countermeasures to mitigate these hazards. As we continue to explore the cosmos and plan for future crewed missions to distant destinations, these countermeasures will play a crucial role in safeguarding the health and well-being of astronauts. The lessons learned from NASA's efforts in this regard also have the potential to benefit both future international and commercial spaceflight endeavours as humanity's presence in space expands.

Triton
Neptune System



“Global color mosaic of Triton, taken in 1989 by Voyager 2 during its flyby of the Neptune system. Color was synthesized by combining high-resolution images taken through orange, violet, and ultraviolet filters; these images were displayed as red, green, and blue images and combined to create this color version. With a radius of 1,350 (839 mi), about 22% smaller than Earth's moon, Triton is by far the largest satellite of Neptune. It is one of only three objects in the Solar System known to have a nitrogen-dominated atmosphere (the others are Earth and Saturn's giant moon, Titan). Triton has the coldest surface known anywhere in the Solar System (38 K, about -391 degrees Fahrenheit); it is so cold that most of Triton's nitrogen is condensed as frost, making it the only satellite in the Solar System known to have a surface made mainly of nitrogen ice.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA00317

Rename the Orbiter to “Rocket Doc Report”

By Joseph S. Butterfield

AMSRO Chief Editor (2023-2024)

For over 50 years the United States has kept its human spaceflight program restricted to Low Earth Orbit. There is much to learn about spaceflight from the status quo, but their teachings can only go so far.

A space program should not collect cobwebs. A space program should continuously be expanding outwards, trying new things, making mistakes, learning lessons, accumulating knowledge, and exploring the unknown.

If we do not embark on such a quest, then what are we getting for our tax dollars, not to mention all the work-hours, human energy, and intellectual capital expended?

There is no future in Low Earth Orbit. An orbit is not a destination. An orbit is a flight path that goes around a celestial object.

Imagine riding your bicycle around the block, not just once, but one hundred thousand times. Are you really doing any exploring, or learning anything new?

To that effect an “Orbiter” is a type of spacecraft that flies around a celestial object over and over and over again. This newsletter was named after the Orbiter of the Space

Shuttle system, which is sort of understandable because the origin of AMSRO occurred during the Shuttle Era. But the Shuttle has been gone for 13 years and our future does not involve more orbiting. We've done enough orbiting.

Our future involves stomping across the solar system and building bases out there.

Given that our generation and the generations to come will pursue a different path, it is time to retire the name "Orbiter" for this newsletter.

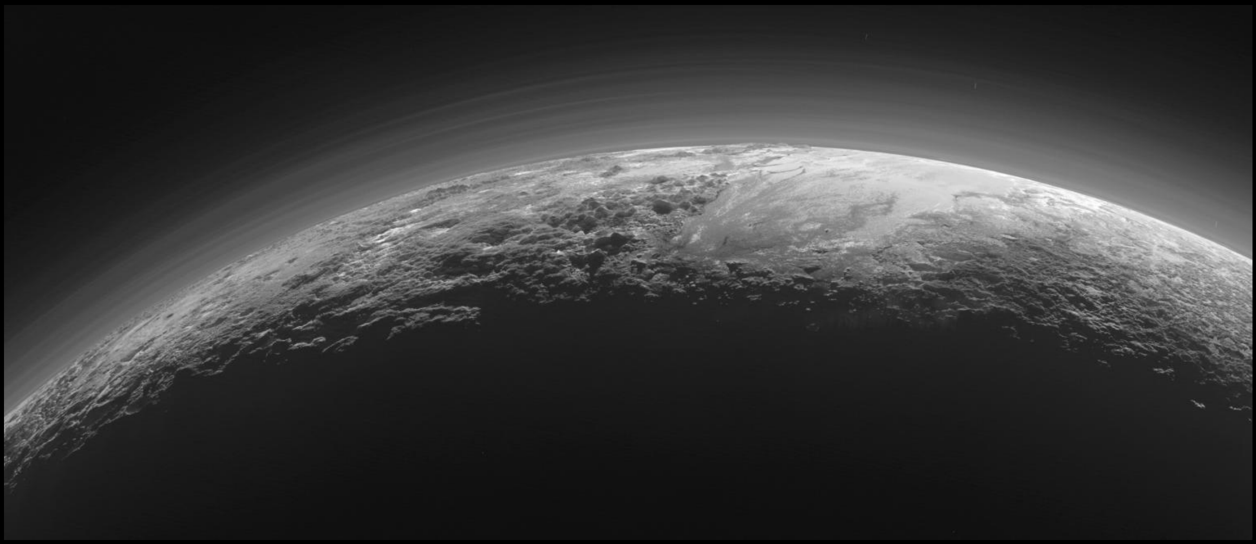
Earlier in this cycle I hosted a poll to solicit feedback for a name change to this newsletter. Those who favored a name change were 5% of the membership, and those against were 8%. Due to the 3% edge of those opposed, I took no action. But 87% of AMSRO did not respond to the poll, and so the poll itself is probably meaningless due to low turnout.

However, several suggested new names were volunteered. The best name was "Rocket Doc Report." I wish I knew who suggested it, but all submissions were anonymous.

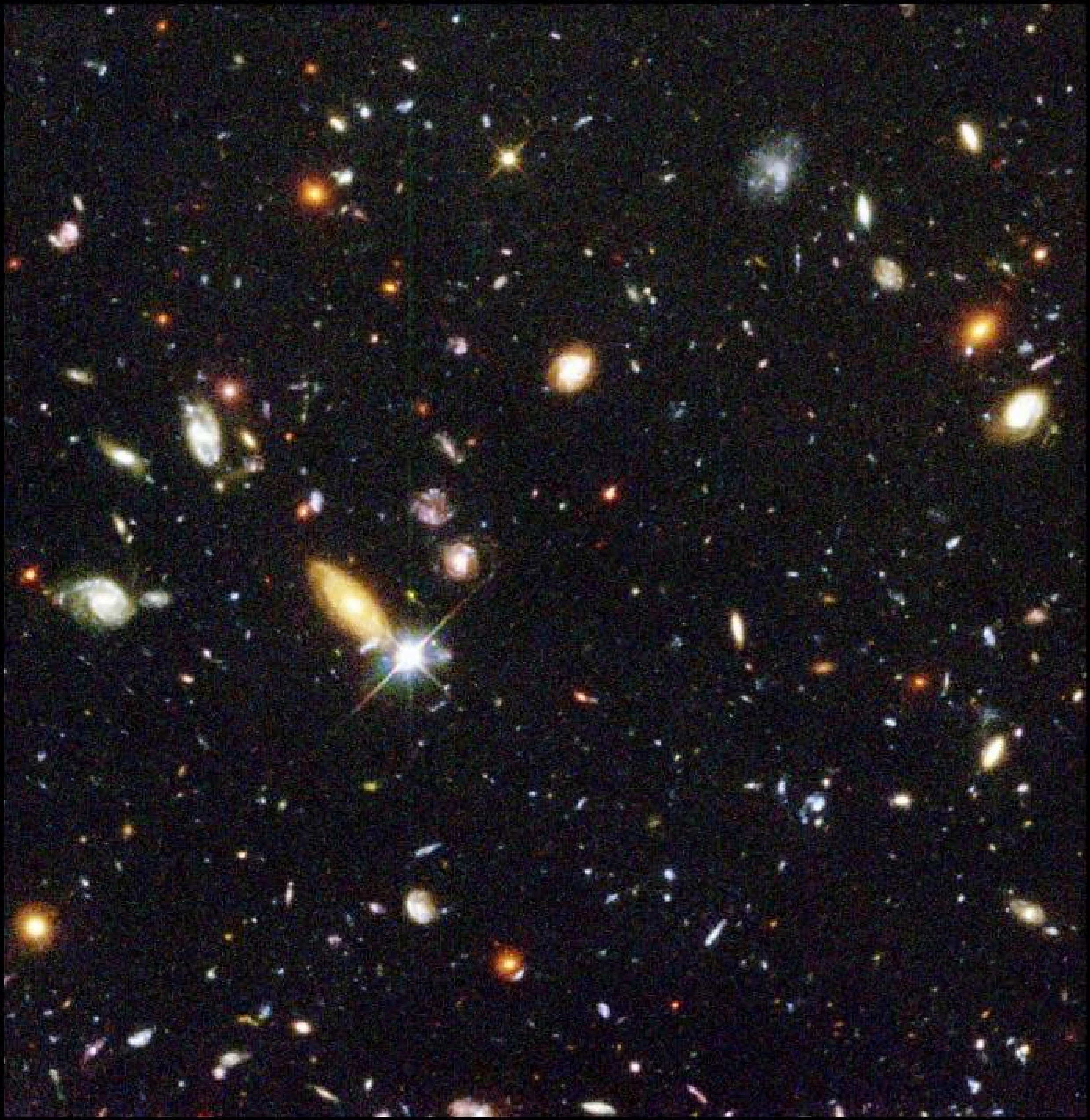
As the outgoing Chief Editor, I officially endorse changing the name of this newsletter to "Rocket Doc Report."

It's a very cool name.

Pluto



“Just 15 minutes after its closest approach to Pluto on July 14, 2015, NASA's New Horizons spacecraft looked back toward the sun and captured this near-sunset view of the rugged, icy mountains and flat ice plains extending to Pluto's horizon. The smooth expanse of the informally named icy plain Sputnik Planum (right) is flanked to the west (left) by rugged mountains up to 11,000 feet (3,500 meters) high, including the informally named Norgay Montes in the foreground and Hillary Montes on the skyline. To the right, east of Sputnik, rougher terrain is cut by apparent glaciers. The backlighting highlights more than a dozen layers of haze in Pluto's tenuous but distended atmosphere. The image was taken from a distance of 11,000 miles (18,000 kilometers) to Pluto; the scene is 780 miles (1,250 kilometers) wide.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA19948



Hubble Deep Field HST • WFPC2

PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

“Several hundred never before seen galaxies are visible in this "deepest-ever" view of the universe, called the Hubble Deep Field (HDF), made with NASA's Hubble Space Telescope. Besides the classical spiral and elliptical shaped galaxies, there is a bewildering variety of other galaxy shapes and colors that are important clues to understanding the evolution of the universe. Some of the galaxies may have formed less that [than] one billion years after the Big Bang.” Read more: https://photojournal.jpl.nasa.gov/catalog/PIA12110