Venus & Mars
2020 Script

This script accompanies the PowerPoint: Venus & Mars: Space Travel Differences in Women and Men

[Highlighted Slide numbers indicate where the presenter should click to advance the slide or show a new section on a current slide.]

We're going to be talking today about how space travel may or may not affect men and women differently. It's a timely and important topic, with several nations and some private organizations planning to send people back to the Moon or to Mars.

This presentation was prepared by Loretta Hall, a self-proclaimed space buff. She is a freelance writer who is primarily interested in researching and writing about humans preparing for and ultimately achieving spaceflight. She has written five books about space travel topics. She is a Certified Space Ambassador for the National Space Society, a great organization that works to promote manned space exploration. Its Space Ambassadors give presentations like this one to inform people about space exploration and hopefully generate interest in and enthusiasm for space missions. The NSS also develops education programs and sponsors competitions for students around the world to help them learn about space exploration. And they work to influence America's space policy. You can find out more about the National Space Society and its programs at nss.org.

The expression Amen are from Mars, women are from Venus@ came from a book with that title that was published in 1992. And for the past 25 years, it's become a common way to refer to inherent differences between the sexes, mostly from a psychological or emotional perspective. But it seems appropriate to use that terminology for an examination of how space travel may affect male and female astronauts differently or not whether it be psychologically, emotionally, or physically.

Slide 2 Let's start by getting some perspective. As of October 31, 2020, 556 people have been to space; 65 were women (11.7%). NASA has sent 338 astronauts into space, including 46 women (13.6%); 53 NASA astronauts have served as crew on the ISS, including 13 women (25%). So, America is looking comparatively good in terms of sending women to space.

Slide 3 One reason that there have been fewer women is that they got a late start. The Soviet Union sent the first human (Yuri Gagarin) into space on an orbital flight in mid-April 1961. Alan Shepard was the first American, with a suborbital flight 32 weeks later. NASA's first orbital flight came in February 1962. The Soviet Union sent the first woman into space in June

1963 (more about that later), but the United States didn't send a woman to space until 20 years later (June 1983). Since then, however, the US has sent the most women into space: 50 of 334 NASA astronauts (15%). The USSR/Russia (4/121; 3%). Canada, China, and Japan have sent two each; and France, Italy, South Korea, and the United Kingdom have sent one each.

Slide 4 Another reason is that, in some ways at least, women are more susceptible to damage from cosmic radiation. On Earth, they are more likely to develop radiation-induced cancers primarily in the lungs, thyroid, breasts, uterus, and ovaries. NASA's guidelines for radiation exposure are based on limiting the increased likelihood of dying from radiation-induced cancer to 3%. That risk is related to age, because the older you are, the sooner you will die anyway.
This 2010 table summarizes the guidelines based on astronaut age, with the estimated length of life lost for those who develop a fatal radiation-induced cancer. It's from a publication titled Radiation Risk Acceptability and Limitations.

Slide 5 Even those limits can allow some impressive accomplishments. Last year, NASA astronaut Peggy Whitson completed her third mission aboard the International Space Station. In 2017, she set a new record for the most total time in space for **any** NASA astronaut, breaking the old record of 534 days, 2 hours, and 48 minutes (held by male astronaut Jeff Williams). By the time she returned to Earth, she had spent 665 days 22 hours 22 minutes in space during her three trips. She performed ten EVAs, which tied Michael Lopez-Alegria for the most by a NASA astronaut (one Russian cosmonaut has done 16). Her total EVA time is 19 minutes less than Michael's C not bad for a girl, though! Peggy's first trip to space was in 2002, and her second was in 2007. In order to comply with the radiation exposure limits, she didn't take her third trip until 2016, when she was 56 years old (the previous record was 55 for women). As we saw in the table on the previous slide, the radiation exposure limits increase with the astronaut's age.

Slide 6 More recently, NASA astronaut Christina Koch [Cook] spent 328 consecutive days in space on an ISS mission. That is the longest single-mission stay for a female astronaut, passing Peggy Whitson's mark of 289 consecutive days. The only NASA astronaut with a longer single- mission spaceflight is Scott Kelly, with 340 days (520 days cumulative). During her time in orbit (90 percent of a year), she performed six EVAs with a total of 42 hours 15 minutes working outside the spacecraft.

Slide 7 Before we get into more specifics about the different effects of space travel on men and women, let's look at the history of women in space. America's first astronauts, the Mercury Seven, were selected in 1959. An important part of the selection process was the extensive physical examinations the candidates underwent at the Lovelace Clinic here in Albuquerque. As some of you may be aware, after those exams were finished, Dr. Randy Lovelace was intrigued with the idea of women as astronauts. He thought they might have several inherent advantages, for example he noted that:

> Women are less likely than men to have heart attacks. Women are generally smaller than men.
> They need less oxygen than men.
> They eat less than men.
> Female reproductive organs are internal, making them less susceptible to radiation. They may be better able to withstand isolation and confinement than men.

So, 25 highly-qualified, civilian female pilots volunteered to undergo the same physical exams
as the male astronaut candidates had. Thirteen of them performed at least as well as the Mercury Seven had. They became known as the Mercury 13, although they were never officially astronaut candidates. Jerrie Cobb was the first one who came

to the Lovelace Clinic for the exams, and she subsequently helped identify other female pilots to invite. Jerrie's exam results were in the top 2 percent of the results of the 35 male astronaut candidates. A *Time* magazine article about her in August 1960 reveals the male/female culture of that era. Here are

Slide 7 insert a few excerpts:

A slender (5 ft. 7 in., 121 lbs.) blonde
The first astronautrix (measurements: 36-27-34)
Perhaps in late 1962 Jerrie Cobb will don a formless pressure suit, tuck her ponytail into a helmet and hop atop a rocket.

Slide 8 NASA was not interested at that time in sending women to space, but the Soviet Union jumped on the bandwagon. I've read differing accounts, some suggesting simply that as part of the Cold War Space Race, the Soviets sent Valentina Tereshkova on an orbital mission in 1963 to show that their form of government was better than America's. I've also read that Nikolai Kamanin, the head of the Soviet cosmonaut corps at that time, made several comments in his diary about the United States' plans to launch a female astronaut probably because of press coverage about the Mercury 13.

Slide 9 After that political and psychological power play, though, the Soviets didn't send another woman into space until 1982, after NASA had accepted its first female astronauts and was clearly preparing to send one into orbit. Svetlana Savitskaya spent about a week on the Mir space station 10 months before Sally Ride became the first American woman in space. Whether Soviet women had better societal standing than American women is unclear, though. When Savitskaya boarded Mir, the men aboard the space station presented her with a welcoming gift: a floral-printed apron. And the Soviet press didn't treat her any better than *Time* had treated Jerrie Cobb. An *Izvestia* article said, Ashen is charming and soft, a hospitable hostess and likes to make patterns and sew her own clothes when she has time to spare. *Taas* reported, "She is a young, slim and petite woman in a modest dress, with a beautiful jacket over it. The hazel, somewhat thoughtful eyes look out from under the fringe casually swept aside."
In early 1984, NASA announced that Kathryn Sullivan was going to perform a 32 -hour spacewalk during a mission the following October. The Soviets quickly reactivated Savitskaya and sent her on a mission in July, during which she performed a 3 hour and **35** minute EVA.

Slide 10 Since those early years, 65 women and 500 men have traveled to space. Four of the women have been Soviet/Russian and 51 have been American. Women astronauts have also hailed from Britain, France, South Korea, Italy, and two each from Canada, China, and Japan. What have we learned from that experience? Not much, it turns out. With only 12 percent of space travelers being female, the sample size is too small to draw firm conclusions, particularly when there are clearly individual differences in the way space affects different individuals (both male and female). Most of the information we're going to cover in the rest of this session comes from two sources, ASex, Space and Environmental Adaptation, published in 2002 and The Impact of Sex and Gender on Adaptation to Space@ in the November 2014 issue of the *Journal of Women's Health*. Let's look at half a dozen categories with potential sex-related differences and see what is now known or suggested from experience.

Slide 11 Based on the studies reported in these two resources, we're going to look at these areas of concern: muscles and bones, the heart and circulatory system, the immune system, sensory organs and motor control, reproductive and urinary systems, and behavioral health during spaceflight, and what differences there may be between male and female astronauts.

Slide 12 First, we'll look at the musculoskeletal system. Microgravity is the main cause of deterioration in muscles and bones. Muscles don't have to work as hard to support the body or move objects when they are essentially weightless, so they tend to lose their strength. Bones don't have to support the body's weight, so their mineral density decreases. Scientists are not sure yet exactly how this happens, but they are studying the process so they can better protect astronauts against bone loss.

Studies of astronauts in spaceflight and also in Neutral Buoyancy Tank practice sessions for EVAs have found that the most common injuries are to the hand, back, and shoulder. The most common injury types were abrasions, contusions, strains, and lacerations. The leading causes of the injuries were onboard activities like between modules and exercising, and injuries caused by the extravehicular activity (EVA) suit components. The in-flight injury rates you see here are based on 198 to men and 21 to women from the Mercury Program through December 2006, which includes part of the Space Shuttle era (construction of the ISS began in late 1998 and was ongoing during this period; ISS has been continuously occupied since Nov 2000). During that time, total person-hours in space comprised 86% male and 14% female. Men experienced 90% of the injuries and women had 10%, but the difference may not be statistically significant because of the small sample of women.

Slide 13 Current studies show that astronauts lose as much as 1.5% of their bone density each

month that they spend in space. After they return to Earth, their bones regain normal density over time, which has taken as much as 3 years. Bone loss results in higher levels of calcium in the urine, which can lead to renal stone formation. We will talk more about that later in the presentation, but for now, we'll note that male astronauts seem to be more prone to that particular problem than female astronauts.

Slide 14 The greatest bone loss takes place in the pelvis and thigh bones. In men, those bones are heavier than they are in women. So since there's more bone there to start with, it seems like it should be stronger even after some bone loss. But a study of 42 astronauts on the first 32 missions to the ISS found that crew members who started with more BMC [bone mineral content] end up losing more bone faster than crew members who started with less BMC. In fact, bone loss in spaceflight is the same in men and women.

Slide 15 How can bone loss be prevented or at least slowed? There are 3 ways, and they are all important. One is nutrition. It's important, for example, to include enough vitamin D in the diet or by supplements. Nutritionists have made sure astronauts get the recommended amount of iron in their diets, but they are now discovering that they don't need as much iron in space because the blood volume decreases; and the extra iron in their systems seems to be promoting bone loss. In addition to proper nutrition, bone loss can be combated using drugs that have been developed for osteoporosis patients here on Earth. Some of the drugs being investigated are hormone therapy (estrogen and/or progestin) and bisphosphonates. Alendronate, a bisphosphonate, was shown in one study on the ISS to prevent bone loss in the hip when used with an appropriate exercise regimen. Which brings us to the third strategy for limiting bone loss: exercise.

Slide 16 The right kind of exercise can also help prevent the other main musculoskeletal problem in space: weakening of muscles. A study published in 2009 found that astronauts who stayed on the ISS for 6 months experienced a 15% loss of muscle volume and a 25% loss of strength. And these astronauts had been spending a couple of hours a day using exercise equipment for strength doing things like riding a stationary bicycle, running on a treadmill, and doing various exercises like squats and lifting weight with a bar attached to resistance. The bike and the treadmill required harnesses to keep the astronaut in position. The simulated weight equipment they, which was called the Interim Resistance Exercise Device (iRED), used elastic bands as resistive force. The resistance wasn't consistent; it got stronger the farther it was stretched. And it turned out the maximum amount of resistance wasn't enough. Also, astronauts had to wear a hefty harness when using the iRED for certain exercises, and that harness pressed against the shoulders and could rub against the skin.

Slide 17 So NASA developed new exercise equipment, the Advanced Resistive Exercise Device (ARED) that provides a high-weight, low-repetition workout with twice as much resistive force as the iRED. The resistance is produced by vacuum cylinders for a constant resistance, and flywheel assemblies provide a variable resistance to mimic the inertial forces generated when lifting free weights on Earth. And astronauts don't have to use a harness for any of its 29 different exercises. In comparing the iRED and ARED exercise devices, a NASA- funded study found that men and women lost proportional amounts of bone using iRED but the ARED system protected against loss of bone mineral density in men and women equally. The ARED exercise group did not lose bone (in the whole body or specific regions), but they gained lean mass and lost fat mass during flight, whereas the iRED group lost bone and lean mass and gained fat mass. [Men and Women in Space: Bone Loss and Kidney Stone Risk after Long-Duration Spaceflight, *Journal of Bone and Mineral Research*, July 2014]

The bottom line, in terms of our Mars and Venus comparison, is that men and women fare about the same in space as far as muscle weakness and bone loss are concerned.

Slide 18 On the other hand, male and female astronauts don't start out with the same physical capabilities. Women, on average, are 4 inches shorter than men and weigh almost 30 pounds less. They also have 11 percent more body fat, 8 percent less muscle mass, 10B14 percent less hemoglobin mass, and a lower level of aerobic fitness than men. Their lower body strength is 70 percent of men's, but their upper body strength is only 50 percent of men's. During intense exercise, women experience a higher heart rate, higher body temperature, greater stress, and quicker onset of fatigue; however, women tend to have greater endurance for sustained exercise because of their greater reliance on fat metabolism. It makes sense to take these average characteristics into account when assigning duties in space, especially for EVA activities that require vigorous upper body work.

Slide 19 Next, let's look at the cardiovascular system. Here on Earth, gravity keeps body distributed normally in the body. In space, without that gravitational pull, fluids shift upward, producing the familiar puffy faces and upper body you see in astronaut images. What you may not notice so much is the corresponding reduction in size of the legs, and effect lovingly referred to as chicken legs.

Slide 20 Remember that one of Dr. Lovelace's reasons for considering women as astronaut candidates was their heart health. In fact, under age 55, women are less likely to have heart attacks than men, and their heart attacks tend to be smaller and nonfatal. Women's hearts are smaller than men's, and they pump faster but with lower pressure. Women respond to stress by increasing heart rate, while men respond by increased vascular resistance. Both responses increase blood pressure, but in different ways. Male and female hormones also play a role in blood pressure. So cardiovascular system differences are complex.

Slide 21 In space, two differences are interesting to note. One is that when astronauts return to Earth, women experience orthostatic [upright posture] intolerance more than men. In layman's terms, that means they have more difficulty standing for long periods without fainting. This may not be surprising, since women are twice as likely as men to experience vertigo (a sense that they, or their environment, are moving or spinning, even though there is no movement) on Earth. The fact that women lose more blood plasma volume while in space than men do may be a factor. Also, women have lower vascular resistance in the legs than men, which can interfere with pushing blood back up to the brain. A 2015 NASA study found that historically, more than 80% of female crewmembers experienced symptoms like lightheadedness during postflight tests, compared to about 20% of male astronauts. That is a temporary condition that doesn't last more than a day.

Slide 22 Another cardio-related effect of spaceflight is visual impairment intracranial pressure (VIIP). This is one of the most problematic issues at this time, because it can affect the vision of astronauts both temporarily during their mission and permanently after the mission. Some astronauts prepare for this by bringing several pairs of reading glasses with them for their mission so they can use increasingly strong corrections as their vision degrades. Researchers are working to develop adjustable-vision glasses using liquid crystals. Several possible causes of VIIP are being investigated. One is increased pressure in the body's fluid-conducting vessels and ducts; this may cause engorgement of the optic nerve sheath and pinch the optic nerve itself. Another is that the fluid shift to the upper body increases pressure inside the skull, pressing against the eyeball and flattening it. There is also some evidence that genetic predisposition may play a role.

Slide 23 A 2014 study found that 82% of male astronauts are affected (14 out of 17 studied) versus 62% of female astronauts (5 out of 8 studied). The difference was not statistically significant, probably because of the small number of subjects (especially females) that were studied. But the study did report that All clinically significant cases described thus far have occurred in male astronauts, while female astronauts have exhibited much milder visual impairment symptoms.

Slide 24 Now let's consider the body's immune system. Studies on Earth indicate that women produce a more potent immune response than men. They have more resistance than men to viral and bacterial infections; and, when they are infected, women mount more robust responses.
Unfortunately, these robust responses may result in autoimmune disorders. Still, a strong immune response can be a useful attribute in space, in case of an injury, for example, or exposure to harmful germs. Astronauts perform a weekly house cleaning on the ISS, using a vacuum cleaner and liquid detergent to collect dust and disinfect surfaces. But it's still not a sterile environment.

Slide 24 insert This picture shows fungi cultured from a sample collected on the ISS. Various bacteria are common in spacecraft like the ISS, and some grow more rapidly or more potent in microgravity. For instance, in one experiment, E. coli grew almost twice as fast as a control sample on Earth. In another experiment on a space shuttle, genetic changes were observed in salmonella that made it almost three times more likely to cause disease in mice than the control sample grown on Earth. Another study two years later found salmonella to be three to seven times more virulent in space than on Earth. So strong immune responses would be important for astronauts.

Slide 25 We just talked about bad microorganisms, but there are good ones too. In fact, each human being develops its own microbiome consisting of trillions of microorganisms living on the body and in various internal places, particularly the gut. They're important for digestion and nutrition, and also for the immune system. They consist of more than 10,000 species, primarily viruses, bacteria, and fungi. For decades, scientists believed that there were 10 times as many microbial cells as human cells in and on our bodies. A recent reevaluation of the estimate, though, indicates that the number of each type of cells is about equal. Interestingly, there are distinct differences in the microbiomes of men and women.

Slide 26 Each of us hosts a microbiome that is about as unique as a fingerprint. In a 2015 study, researchers were able to identify individuals just by analyzing the bacteria they left in the air and it took them only four hours to do it. Strangers have only 10% of their microorganisms in common, but after two people spend time in close contact, like spouses for example, they eventually have 90% of their microorganisms in common. So, some amount of microbiome mixing is bound to take place between astronauts on the ISS. How that may affect their health is unknown. Spaceflight itself creates changes too, in response to stress, radiation, microgravity, and dietary changes. Research on male astronauts has already shown a decrease in beneficial microorganisms in the gut, and in the nasal and oral pathways in both long and short duration stays in space. Only male astronauts were studied for those effects, so we don't know if that is also true of female astronauts.

Slide 27 As a practical matter, what does this mean for astronauts? Some researchers suggest adding probiotics and fermented foods be included in space mission diets to maintain healthy gut microbiomes. In the case of illness or infection requiring antibiotics, it is important to realize that germs and antibiotics act differently in microgravity and can affect microbiomes. This may affect women in particular because of their susceptibility to breast cancer, ovarian cancer, or a urinary tract infection during an extended journey in space.

Slide 28 NASA has found several sensorimotor issues in spaceflight, including changes in control of movement, changes in the ability to see and interpret information from the eyes,

problems with spatial orientation, space motion sickness, and difficulty walking after returning to Earth. And the longer the duration of space travel, the more intensely astronauts are likely to experience these symptoms. The issue that seems to have gotten most attention from NASA is A space adaptation syndrome@ or A space motion sickness (SMS). The symptoms include pallor, increased body warmth, cold sweating, malaise, nausea, fatigue, vomiting, and loss of appetite or the ability to eat. These are things that can prevent astronauts from functioning effectively for a day or two or three.

NASA conducted a series of tests at Johnson Space Center of more than 200 people in a variety of procedures that might cause motion sickness like sudden stop, off-vertical rotation, or parabolic flight. They found no differences between men and women here on Earth.

During post-flight debriefings after both short-duration spaceflights on the space shuttle and long-duration missions to the ISS, 50% of female astronauts reported experiencing SMS, compared with 38% of the male astronauts. The sample size for short-duration missions was large (564 male, 100 female astronauts), but the long-duration sample was only 32 men and 10 women. It's interesting that on return to Earth from long-duration space missions, the effects are reversed, with men reporting SMS symptoms more often than women. The sample size for women is small, though, so the results are not statistically significant.

Slide 29 The next topic is the genitourinary system, which involves both reproductive and urinary systems. We'll look at reproduction first. As mentioned earlier, one of the reasons Dr. Lovelace thought women might be better suited to spaceflight was that their internal reproductive organs are internal and, therefore, better protected from radiation. This is true to some extent, as indicated in this table from the European Space Agency. Another source said that temporary infertility is associated with high-dose, acute radiation exposure of 150 mSv (millisieverts) acute x-rays for men (as shown here), and 650 to 1500 mSv acute x-rays or gamma rays for women a factor of 4 to 10 compared to men. As the chart indicates, male testes are the most sensitive part of the body to radiation. Next in sensitivity are the eyes and bone marrow.

This apparent advantage for women is offset by their higher incidence of radiation-induced cancers, mainly in the lungs, thyroid, and ovaries. As we mentioned earlier, that is why women's time in space is more limited than men's time.

Slide 30 Another factor that historically led to reservations about women going into space is menstruation. Even at the time of the Mercury 13 testing in 1961, it was widely accepted in the medical community that women were less attentive, more accident prone, and even more likely to attempt suicide during or just prior to their monthly cycle. There was serious concern that they would be unable to perform safely in space during that time. When NASA started preparing to send women into space, the engineers had to figure out what additional supplies had to be prepared. They asked Sally Ride if 100 tampons would be the right number for a 7- day mission. (They also tried to figure out what to include in a makeup kit for women in space.) To be fair, menstruation in space does raise some practical issues. On the ISS, urine is recycled into usable water, and introducing any blood into the system would complicate the reclamation process. There is also concern about the amount of waste material that has to be collected and stored on the station. In fact, most female astronauts choose to suppress their menstrual cycles while in space, taking oral contraceptives without the 1-week placebo or using a hormonal IUD.

Several other factors affect male and female astronauts as far as reproduction is concerned. Age is one of them that women contend with. The average age of an incoming female astronaut is 32, and many of them want to delay pregnancy until after their first spaceflight. Flight schedules are unpredictable and flight training is demanding, so most are approaching 40 by the time an appropriate window opens for them to conceive. That moves them into the increased risk category for pregnancy problems. Male astronauts' ability to conceive children is not affected by flight or training schedules.

Slide 31 A 2005 study of American male and female astronauts after space shuttle missions averaging 9 days each show these family-producing experiences. The results for miscarriages are similar to the general population of women, who experience miscarriages at a rate of 33% at age 40 and 50% at age 45. The results for chromosomal abnormalities are also typical of the general female population, which experiences 1 in 60 at age 40 and 1 in 40 at age 42.

Slide 32 The other part of the genitourinary system takes care of processing, storing, and eliminating liquid waste from the body. Again, we'll look at two issues that pertain to spaceflight. First are urinary tract infections. 80% of diagnosed UTIs occur in women, for a couple of reasons related to our anatomy. The urethra is close to the anus, which encourages bacteria to transfer from one to the other. Also, the female urethra is shorter than the male, so bacteria find their way into the bladder more quickly, and then up toward the kidneys. Urinary tract infections can be treated with antibiotics, but as we've seen, antibiotics may not be as effective in space, and bacteria can be more virulent. In NASA's history, there have been 9 cases of UTI during spaceflight, most in women.

Slide 33 Both men and women have experienced some difficulties with urinating in space. There are several reasons. For example, they sometimes have to delay urination because of the work they're doing or because the bathroom isn't available. In microgravity, it's not easy to feel the need for urination until the bladder is really full. Voiding is less natural without the action of gravity. One study examined data from the Mercury Program through the first 38 space shuttle missions (through 1990) and found that there have been 16 cases of urinary retention in space. Four of them had to be resolved by inserting a catheter; all of four of those were for women. In 12 of the 16 cases, the astronauts had taken medication for space motion sickness. An astronaut experiencing urinary retention is 25 times more likely to have a UTI.

Slide 34 The other potentially serious problem with the urinary tract is the formation of kidney stones. So far, only one cosmonaut has experienced that in space, but by 2007, 12 NASA astronauts had developed them; 10 were men and 2 were women. On Earth, men are twice as likely as women to develop a kidney stone during their lifetime (13% to 7%), but the types of stone are different. Men tend to develop calcium oxalate stones, which are related to dehydration and excess calcium in the body both of which tend to happen during spaceflight. Women tend to develop struvite stones, which are related to urinary tract infections, which they are more prone to than men. In other words, it can be a problem for both sexes.

Slide 35 Finally, let's consider the effects of spaceflight on behavior. A study of astronauts living on the ISS found no differences between men and women in terms of alertness, tiredness, stress, sleep quality, or perception of the appropriateness of the workload, either in space or after returning to Earth. On Earth women are twice as likely as men to experience anxiety and depression, but because of the extensive psychological screening of astronaut candidates, this is unlikely to apply to spaceflight. As far as confinement in a small group setting is concerned,

studies have found that mixed-sex groups function best. At least among US astronauts, the Mercury/Gemini/Apollo macho apace cowboy@ attitude seems to be diminishing.

Remember that one of the reasons Dr. Lovelace wanted to test women as astronaut candidates was that there was some evidence that they might be better able to withstand isolation and confinement than men. In fact, one of the tests the Mercury astronaut candidates took at the Aero Medical Laboratory at Wright Patterson AFB in Ohio was an isolation test. It consisted of sitting at a desk for 3 hours in a dimly lit room. As one example, John Glenn occupied himself by writing poetry. But the isolation tests Jerrie Cobb and two other members of the Mercury 13 took later at the VA hospital in Oklahoma City were much more severe; they were actually sensory deprivation tests. Each had to float in a tank of water that was maintained at her specific skin temperature, with the air also maintained at that temperature, in complete darkness for as long as she could without starting to hallucinate. The only thing they had to keep them afloat were two Styrofoam pads, one behind the neck and one in the small of the back. The longest a man had been able to endure this was 6 hours and 20 minutes. Jerrie

Cobb lasted 9 hours and 40 minutes. The other two women, Wally Funk and Rhea Hurrle, each lasted more than 102 hours. In all three cases, the staff ended the tests without the woman calling for a stop.

Slide 36 We've covered a lot of physiological territory today. Let's summarize what we've found out. Women and men have about the same results for both muscle strength and bone loss. Women of astronaut age are less likely to have serious or fatal heart attacks, but they are more likely to have problems with dizziness and balance immediately after returning to Earth.
Upward fluid shift in microgravity increases pressure in and around the brain, often causing vision problems that can be permanent. Men are much more susceptible to those vision problems. Women generally produce stronger immune responses than men, and this can be useful in space, where germs thrive, infections can be more severe, and antibiotics may not be as effective. We know that male astronauts experience a decrease in beneficial microorganisms in the gut, and in the nasal and oral pathways in both long and short duration stays in space; but we don't know if that also happens to female astronauts. Women are more likely to experience space motion sickness when starting their space mission, but men are somewhat more likely to experience it when they return to Earth. Women's internal reproductive organs are better shielded from radiation, but women are more prone to develop radiation-induced cancers. As a result, NASA's guidelines for individual and total space mission durations are longer for men than for women. Women are more likely to develop UTIs during spaceflight. Men and women may develop kidney stones after spaceflight, but the causes are different. Behavioral issues don't seem to be different between the sexes.

So, it appears that there is no clear advantage to either men or women as astronauts. But researchers generally agree that more women should be sent on space missions to increase the sample size and provide better information on potential health issues and how they may differ from men's potential health issues.