AN ADVENTUROUS MIND
BONNIE DUNBAR

THE ORAL HISTORY OF WASHINGTON'S FIRST WOMAN ASTRONAUT

LEGACY PROJECT
Washington Office of Secretary of State

THE WASHINGTON STATE
HERITAGE CENTER

Bonnie J. Dunbar, PhD

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Heffernan: Washington native Bonnie Dunbar chased her dreams from a humble cattle ranch in small town America to the vastness of space. The only Washington woman to brave the Final Frontier, Dunbar is one of just 51 female astronauts in the world to make the same journey. By the end of her career as an astronaut, the five-time space hero soared across more than 20-million miles in outer space. Having lost none of her enthusiasm or passion for America's standing as the space leader, Dunbar is busy recruiting the next generation of science heroes.

Known for her trademark modesty, Bonnie Jean Dunbar says she's no hero. But her world-famous accomplishments on and off the planet have inspired youth and colleagues alike. *NASA photo.*

This is Trova Heffernan for The Legacy Project on June 19, 2009. It is our sincere pleasure to capture the inspiring story of Dr. Dunbar from Seattle's Museum of Flight, where she is currently CEO and President.

Heffernan: I had such a good time reading some of the articles that have been written about you, particularly in the UK.

Dunbar: Oh, really! What did they say in the UK?

Heffernan: One writer refers to you as "…a more attractive version of Jane Fonda, slim and stylish, and a veteran of five space flights." (laughing) She goes on to call you a "Treckie man's goddess."

Dunbar: A Treckie man's goddess? (smiling)

Heffernan: There aren't many people who can say this, Dr. Dunbar.

Dunbar: I did not read this.

Heffernan: So, what do you think of this side of fame and celebrity?

Dunbar: Well… (laughs) I don't dwell on it. I think it's kind of amusing. But if anything positive results from an opportunity to discuss human spaceflight and exploration, that's wonderful. That's the "takeaway" you want.

Heffernan: What are some little-known facts about you? You mentioned you can't tell a joke.

Dunbar: Well, they're little known because I don't tell them. (both laughing)

Heffernan: You're helping your own cause. And I take it we're going to keep it that way? (both laughing)

Dunbar: If this had been a onetime book it would be one thing, but now we're on the viral highway.

Heffernan: Fair enough. Okay – down to business. You're a seasoned astronaut with five missions behind you. You broke the gender barrier as a female space pioneer. Is adventure in your blood? As a child, were you adventurous?

The young astronaut beams at nine months.
Dunbar personal collection.

Dunbar: I think it depends on your definition. Was I adventuresome in my own era, in my own environment? Not any more than any other kid growing up on a cattle ranch. Am I adventuresome in today's environment, where many children could be overly protected? Probably.

An adventurer is born. Dunbar and Dad on the family cattle ranch. *Dunbar personal collection.*

I was on a horse before I could walk. My dad would rope me to the saddle. Instead of Sunday drives, we went for Sunday rides. My brother Bobby and I were driving tractors by the time we were nine. We were working in the fields by the time we were nine.

We had our own adventures. My brothers and I would "ride fence" up in the Rattlesnake Mountains by horseback, by ourselves. Were we adventuresome by today's standards? Probably.

But I'm still here. I'm living. I've never had a major injury. I've learned a tremendous amount and gained self confidence. I believe if you acquire self confidence by the age of nine it takes you through the rest of your life.

With brothers Gary and Bobby in the cornfields.
Dunbar personal collection.

Heffernan: What are your fondest memories of life on the cattle ranch?

Dunbar: Well, they're pretty much all fond memories. When you live on a ranch or a farm, years are measured by seasons. Fall is about harvest and starting school. We used to ride to school and the windows would be open on the bus. You could smell the grapes and the peppermint and spearmint being harvested, all these great smells when you started school.

In the spring, you're planting crops after the snow has melted. We picked the rocks out of the field every year. Dad would drive the tractor out with an old bed trailer, very slowly. My brothers and I would walk along the sides, picking rocks out of the field and putting them on the trailer. Mostly, so it wouldn't damage the plow. We'd dump the rocks in this little canyon we had on the property. The canyon had a little stream running through it and very tall trees, where we all had our tree houses.

Heffernan: What an image. What were your tree houses like?

Dunbar: Nails, gunny sacks, and a lot of extra wood. Everything came in gunnysacks, including the grain for our steers. My brother Bobby and I raised steers for nine years in 4-H. We'd raise them and show them at the

Grandview Fair, in the fall. As we'd buy the grain, we'd end up with these really great gunny sacks. We used them with a little bit of rope. The gunny sacks would serve as our hammock. There was a little bit of structure, but not a lot.

We worked very long days. It was very pretty and sometimes hot. But it's not humid heat. It's dry heat. And that was spring.

We planted an then irrigated the crops. We managed the water until harvest. Meanwhile, we still had our cattle, which was our primary revenue generator, for us at least, in diversified farming. The calves are born in the spring. We'd brand them on Memorial Day. That usually brought in a lot of volunteer labor, by the neighbors and friends. We'd work all day long. We'd ride on horseback to round them up in the morning, and then have lunch. In the afternoon, we would start branding and we would finish by dinnertime.

Then we'd have a big cookout. We had friends that could play musical instruments. This is very much like what you see in movies, but it is actually how I grew up. We'd sit around the campfire singing songs.

Heffernan: Do you have musical talent too?

Dunbar: I don't have talent. (laughing) I play the piano. My mother started me when I was nine. I had lessons for about a year. I still have a piano, so I enjoy playing it for myself. My grandfather gave me a violin. He was a fiddle player, a Scottish fiddle player. I started that, but I'm not very good. I'd love to be able to play like he did, by ear, and all of the Scottish folk tunes. He was really quite remarkable.

Heffernan: What were your brothers and sister like growing up?

Before exploring the Solar System, Dr. Dunbar discovered every corner of the family cattle ranch, just outside Outlook in the Yakima Valley. Close with her two younger brothers and sister, they had their own adventures, she says. *Dunbar personal collection.*

Dunbar: I spent most of my childhood with my two brothers because my sister was ten years younger. I had hoped she would be the same age as I when she was born, but that didn't happen. I had always wanted a sister. But by the time I was 18, she was eight. We are now much closer than when we were growing up.

Heffernan: Is that why you're so tough, you grew up with two brothers?

Dunbar: I think it's mostly because of my parents. My brothers were younger. My parents had high expectations for all of us. I was no different than any other son or daughter on the ranch in those days. Sometimes it's survival. Everybody is working. It's a business. No one can afford the luxury of just sitting on the sideline. There are harsh winters. It can get very cold. You can get lost.

Dunbar with her horse Filly in high school. *Dunbar personal collection.*

You can hurt yourself. We were out at the base of the Rattlesnake Mountains where there are coyotes and rattlesnakes. You learn how to survive.

Heffernan: What were your neighbors and the community like?

Dunbar: Well, first we have to realize, Outlook is a post office. It's surrounded by a few houses. But that's not where I grew up. I grew up five miles away from the post office in a ranching environment. *(Editor's Note: Outlook, one of the state's smallest towns, is located near the City of Sunnyside in Central Washington.)*

Heffernan: You know, I've always felt there's something special about smaller communities.

Dunbar: Absolutely. My mother is still on the ranch. One of the things that saddens her most is that she has to lock her doors when she leaves the house. We didn't have to lock our doors when I grew up. We knew everybody. There was that code of conduct and trust. We looked out for each other, we worked hard, and we were supportive.

Heffernan: Tell me about the code of conduct.

Dunbar: Treat others like you want to be treated. Neighbors were considered to be there for a long period of time. There was no value to having long, ongoing feuds. You had to help each other at times of crisis or non-crisis. We'd help each other with harvesting or roundup, when we were inoculating our cattle, or branding them. It was

Branding cattle in the Rattlesnake Hills. *Dunbar personal collection.*

just neighbor helping neighbor. If the harvest came and one neighbor didn't have a piece of equipment, another would loan it.

It was post World War II. I think people were very relieved to come home and to have families. They were thankful for them and thankful for the opportunity to have a nation at peace and a nation that supported democracy and gave them all these freedoms. Something else that maybe our young take for granted.

It was a great childhood. I learned about responsibility at a very young age. I think what I "took away" was a very strong work ethic.

The cattle ranch, a few miles outside Outlook, Washington is shown from space. Here, the Dunbar children work the fields and develop a work ethic second to none. *Google-Imagery photo.*

Heffernan: Finding the happiness in what you're doing.

Dunbar: And seeing the productivity in it. When you're a farm family, you're a team. Everybody participates. We'd get up early before school, sometimes before the sun. Sometimes, we were milking the cows, cutting asparagus, or feeding cattle in the snow in the winter time.

Heffernan: Did you carry the sense of teamwork you acquired working with the whole family throughout your career?

Dunbar: Yes, I think it is part of that culture that you take with you the rest of your life.

Heffernan: Tell me about your parents, Bob and Ethel Dunbar, who were married for 57 years.

Dunbar: My father passed away in 2005. He was born outside of Condon, Oregon. That's where my grandparents had actually homesteaded. My dad was the middle of three brothers. He did very well in math by the way. (smiling) He graduated from high school, but didn't take a scholarship to Oregon State University so he could enter into the Marine Corps to fight in World War II.

He came back after the war and raised cattle. As a veteran, he was able to participate in a raffle of unimproved land in the Yakima Valley that was accessed after The Manhattan Project. It was mostly sagebrush, but not irrigated. His name was pulled out of a hat and he bought it. It was a parcel that had been turned down by about six or seven people in front of him because it was so rocky. But my dad who had studied agriculture in high school, and was in FFA, believed that this was a place he could develop.

My mother grew up in Montana. She was one of nine kids. She was visiting her sister who was in Condon with my uncle. She met my father there in Condon and they were married.

Heffernan: Your parents sure overcame challenges.

Dunbar: They homesteaded in Outlook in 1948, before they had water and electricity. They lived in a tent for about the first nine months of their marriage.

Heffernan: And they were still trucking in water for part of your childhood. Are these hardships an important part of your story? No matter where you come from you *can* achieve your dreams if you work hard. The rules are the same for all of us.

Bob and Ethel Dunbar, heroes to their daughter Bonnie, pose with "Mooney" in 1986 as the family prepares to cross the U.S. *Dunbar personal collection.*

Dunbar: I didn't think of it as hardship at the time. It was life. It's really what is inside of us that counts. Yes, your parents give you some tools. But one of the messages I learned from my parents and my grandfather is that very often we build our own fences. We need to learn that when we don't succeed the first time, we must try again, that's the key. I'm not delivering that for the first time. Those are things that my parents taught me, that they were taught. Those were the rules.

I'm continually disappointed when I hear excuses from kids about why they can't achieve, they have so many more opportunities now.

Heffernan: What kind of excuses?

Dunbar: Well, "I wasn't born into a lot of money, and I don't know the right people, therefore, I can't do it." That's an excuse. Not in this country.

Heffernan: Talk about your own inspiration. Who were your heroes growing up?

Dunbar: That's an interesting question. You know, I'd have to say early spaceflight heroes and my parents.

Heffernan: Your parents because of their journey?

Dunbar: Look at what they did. They started with nothing. They built something. They are also very good people. All my parents ever expected is that we be good productive people, not that we be famous. They encouraged us to take whatever God-given talents we had and use them.

Heffernan: Your grandfather also had a tremendous impact on you.

Dunbar: Yes! Charles Cuthill Dunbar immigrated to the United States when he was 19. My grandfather was very philosophical. He, like many immigrants, came to the United States to have a better life. His part of the clan didn't have land. The Dunbar clan goes back 1000 years. He and his family for several generations had been farm workers. They never had a chance at an advanced education, but he was self educated. He read constantly. Grandfather was *very* self sufficient and believed that freedom was to be valued. He was very proud of his Scottish roots, very emphatic about education, and in fact was eventually on the Condon School Board.

When he immigrated, he had little money in his pocket and a one-way ticket. After arriving at Ellis Island, he worked in upstate New York

As an immigrant from Scotland, Bonnie's grandfather Charles Cuthill Dunbar first enters the United States through the receiving station at Ellis Island.

near Syracuse for a year breaking horses, and earned enough money to come west.

Eventually, he homesteaded in the Condon area of Oregon. He met my grandmother who had emigrated from Scotland, through Canada. He met her at a baseball game in Portland. They were married and had three sons of which my father was the middle son. When grandpa played the fiddle, Grandma used to dance the Scottish Fling. Unfortunately, I never met her; she died before I was born.

I learned from him that if you have a vision, and if you follow your dreams, and you're willing to work for them, this is important. You can't blame anyone else for your failures. My grandfather would *never* take charity. He was accountable for his own success or failure.

Heffernan: Let's talk about other influences in your life like The Space Age. What an interesting time to live. I know you were young, but do you have any memories of Sputnik? (*Editor's Note: Sputnik launched on October 4, 1957. The object, not much larger than a beach ball, made history as the world's first manmade object in space.)*

In 1957, a small Russian satellite launched into orbit, ushering in the space race between the United States and the Soviet Union. For Dunbar, curiosity of the outside world began to take hold. *NASA photo.*

Dunbar: I can envision what I saw or thought I saw. Remember, this was before there were any manmade satellites. The only satellite the Earth had was called the Moon. (laughing) It would have been a small, bright light that was probably not constant. And we would have been told when it was coming over.

In my mind, I remember my parents taking me out to look for it. Everybody was looking for it. People were tuning in to their radios to listen to the "beep, beep, beep" of Sputnik. There was no voice from Sputnik, only a signal. Sputnik was about 23 inches in diameter. If you've ever been down at the space exhibit (at the Museum of Flight in Seattle), we have an engineering test model there from Russia.

Heffernan: How did it compare to a beach ball?

Dunbar: A little bigger. Compare it to the space station. The current space station (International Space Station) is a football-field wide, a big difference.

The International Space Station. *NASA photo.*

Heffernan: Huge difference! So, the excitement of space started to connect with you.

Dunbar: That, coupled with the time of reading Jules Verne, H.G. Wells, of having our first TV and watching Flash Gordon, for example. I only went to two theater movies by the time I was in high school. (laughing) I learned through the TV media, newspapers, and through books. It really was the time of going to space, of Alan Shepard, and John Glenn, and Valentina Tereshkova, and Yuri Gagarin. *Those* had influence on me. But did that make the difference in my career choice? Perhaps. However, many people had the same experiences but not everyone became an astronaut.

I think it just resonated with what I saw. The key is the exposure. That's why I feel so passionate about bringing kids into other environments. I traveled on a lot of field trips. We boarded the bus and we went places. I loved it. I learned from it. It didn't always have a career impact, but the experiences taught. That's how children really know there's something else out there in the world. When they find something that "clicks," and that resonates with them, that gives them a direction and a passion.

Heffernan: Books were such an important part of your passion too, right? I mean Outlook isn't exactly a metropolis.

Dunbar: There were no malls. There were no video games. (laughs) TV was one channel in Yakima. So, I read all the time. It was how we saw the world. It was adventure. No one painted the pictures for us. We painted the pictures mentally. I could put yourself into a book and live it. I just loved reading.

Heffernan: Years later, you – and every American near a television set -- watched the Moon landing unfold, another landmark event of The Space Age.

Dunbar: This is the 40^{th} anniversary, July 20, 1969. In 1969 I was with some of my high school friends and college friends. We all went to the University of

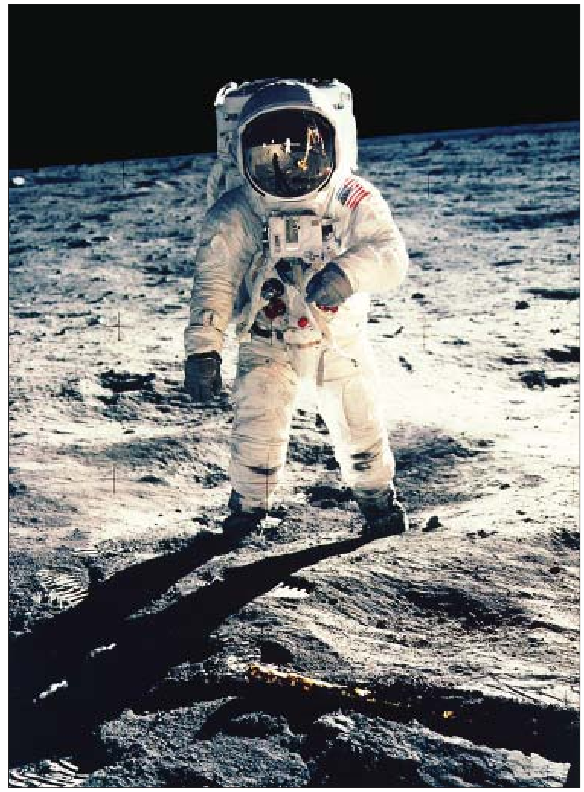
Washington together. We gathered together at one of the parent's homes in Kennewick, Washington.

Heffernan: Do you remember the expressions on people's faces?

Dunbar: Oh, I was not looking at their faces! I was looking at the TV screen. (laughing)

Heffernan: Fair enough. (laughing) Amazed?

Dunbar: Absolutely. I was between my sophomore and junior years, so I was already in engineering. It was exciting. It meant that we were really there.

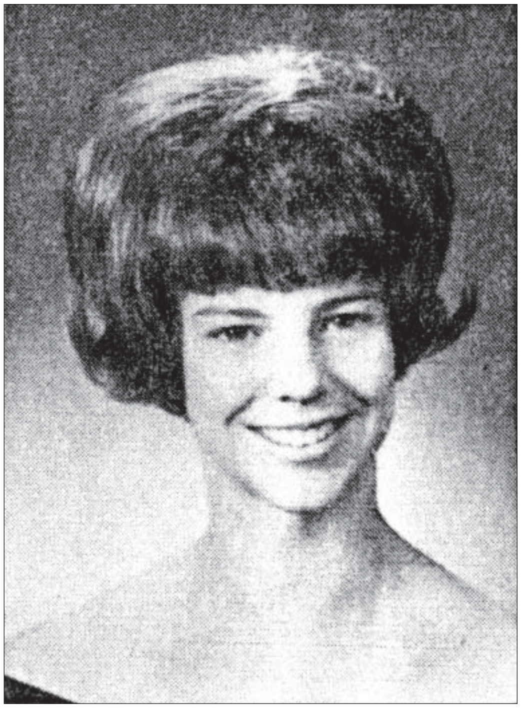


Dunbar was in college when Neil Armstrong and Buzz Aldrin walked on the Moon marking the greatest achievement in the Final Frontier of all time. *NASA photo.*

Sadly, at the same time that we were putting the first two men on the Moon, eventually we put a total of twelve, the program was actually losing its funding. The last three Saturn Vs were never launched. Missions were cancelled. People were getting bored with seeing TV of men walking on the Moon. What we did, I think, was begin to lose our leadership role in space exploration. It may not be noticeable now, but believe me, when other nations land on the Moon, before we return, it will be obvious.

Fortunately, the Space Shuttle program was approved about that same time. And that would be the program that would start to fly – not only a few people but many people to low Earth orbit. It was the first program to include women.

Heffernan: And in fact, you'd become one of the first female astronauts in that program.


Dunbar, the graduate, aspired to build rockets and fly in space. At 18, she made her first attempt to become an astronaut. *Dunbar personal collection.*

So how did it all begin? What were your hopes and dreams as you graduated Sunnyside High School in 1967?

Dunbar: I really wanted to go to college. And I promised my parents that if I had that opportunity, I would. They believed that education was a gift and they didn't have that opportunity. I was very interested in going to college. I wanted to either be an astronaut or build spacecraft.

Heffernan: And you applied to be an astronaut right away. Wow! That sure set the tone for an extraordinary career.

Dunbar: Yes, I applied the first time when I was 18. I received a very nice letter back from NASA – not sure where it is, I'll have to look for it — which basically said that I needed a college education and they would post the announcements in trade journals of some kind.

Heffernan: What a story for a young woman of the '60s! And in short order, you prepared to go to the University of Washington.

Dunbar: I had taken all the math, physics, and chemistry needed in high school. My physics teacher suggested engineering as a way to reach my goals. I was accepted to the University of Washington. I also received a federal grant and loan through the National Defense Education Act which allowed me to afford college.

Heffernan: And so you enrolled at the UW and it's the Hippie Era. What was

Seattle like during that period, 1967- 1971?

Like many college campuses, the UW was the scene of protests and music festivals. But Dunbar tuned out the Hippie Era focusing instead on a career in ceramic engineering. *Seattle Post-Intelligencer Collection, MOHAI.*

Dunbar: I really can't tell you. And the reason is I didn't have a car. I was pretty much confined to the campus. I was in Lander Hall my freshman year, which is about a block off campus. It was the time of the '60s. There was the hippie environment, but I was not part of that.

One of the first things I did when I arrived on campus, was try to join Air Force ROTC (Reserve Officers' Training Corps). But they weren't yet accepting women. I joined the auxiliary at that time called Angel Flight. And there were 50 of us selected from across the campus. It was a community development, community service, and also an Air Force mission-related organization, which still exists as Silver Wings right now. It gave me an opportunity to meet people of like interests, people

Angel Flight, AFROTC Auxillary, 1968. *Dunbar personal collection.*

who loved flight. I loved the structure and the discipline of the United States Air Force.

And I wanted to think of something outside of myself, a mission for my life. Becoming an astronaut, a fighter pilot, serving my nation, those were all things that were of interest to me.


The Reserve Officers' Training Corps (ROTC) is not yet accepting women. Dunbar joins the Air Force ROTC Auxiliary, Angel Flight, shown here in 1969. She was elected Flight Commander in 1970. University of Washington, Tyee Yearbook, pg. 31.

Having an interest in public service, and serving my nation was something I learned from my family. I'm grateful for the fact that I was born accidentally into a nation of freedom. People have died to protect this nation and our values. And I think everybody owes back a little bit one way or the other. They don't have to go in the military, but they owe back to this nation to keep it the way it is.

Heffernan: You found your calling to fly and to serve the country. Did you ever waver?

Dunbar: No, I never wavered and I'll tell you why. It wasn't just about flying. I was lucky. I had purpose in my life. I had discipline and a work ethic. I had to support myself. I started supporting myself when I was 18. If you've got to eat, and pay rent, who does that for you? (laughing)

Heffernan: You were sure a pioneer for women pursuing such a male-dominated and prestigious career at the time.

Dunbar: First, I'd like to just define pioneer. To me, pioneer is the first, and I really wasn't the first. The first woman in space was a woman from the Soviet Union, Valentina Tereshkova. She was followed by Sally Ride in 1983, and there were six American women in that class. I was the second class of women, so there were eight in the United States by that time.

Heffernan: You were the eighth or you were the ninth?

Dunbar: I think I was the seventh or eighth. But I really wasn't counting.

At the Kremlin with the first woman in space, Cosmonaut Valentina Tereshkova. From the left: Tereshkova, Canadian Astronaut Roberta Bondar, U.S. Astronaut Mary Cleave, Cosmonaut Svetlana Savitskaya, U.S. Astronaut Bonnie Dunbar, and Britain's first Astronaut, Helen Sharman. *Dunbar personal collection.*

(Editor's Note: According to NASA, Dunbar is the seventh American woman to fly in space. However, the space agency counts Dr. Sally Ride twice because the Ride flew two missions prior to Dunbar's maiden flight in 1985.) The first women, being the first selected, had to get over that hump. And you need to look at this as a continuum. It was really women going into aviation and space. So, that's a matter of going back to the early parts of the 20th Century. There was the time of Amelia Earhart. Being able to fly as a woman in those early days - those were the pathfinders and the pioneers, who demonstrated they could operate these very complex machines.

Then there was World War II, with the Women Air Force Service Pilots, the WASPs. In fact, a very well known WASP in Washington State just passed away this last week, Marjory Munn, who was a real friend of the museum.

Marjorie Munn. *Munn personal collection.*

Those women ferried airplanes around the United States, flew every airplane that was flown in World War II for the United States. Some lost their lives testing those airplanes, and they were recognized with the Congressional Gold Medal recently. I think it will be awarded in the spring of 2010. So, I think back to those pioneers, the women who learned to fly, brought us through World War II, the women who became stunt pilots, and sport pilots, and won award after award. The next logical progression was going into space.

Heffernan: Did you face skeptics – people who thought as a woman you'd never make it to space?

Dunbar: Some people were discouraging, but most were not. I did have a university professor tell me not to tell people because I'd lose my credibility, but then I also had Dr. Mueller and Dr. Irene Peden.

Heffernan: And you never let them get to you?

Dunbar: No. I had those other professors, and parents, who had faith in me. You learn to ignore the people who aren't supporting you. That's what I learned in life. Why should I listen to them? It's my life and they are not living it.

You can substitute any career for astronaut, or any business. You just have to commit yourself to it and not be deterred by other people or obstacles. Believe in it. Recognize that there will be ups and downs. No path is ever straight, nor is it ever easy. My career wasn't easy at times. But if you believe in your calling, if it excites you when you wake up in the morning, why would you make another choice? Why would you choose something that doesn't make life worth living? The journey alone will be worthwhile.

Climbing out of a T-38. *Dunbar personal collection.*

Heffernan: What were some of the challenges you faced?

Dunbar: How was I going to be able to fund going to college? If it hadn't have been for the National Defense Education Act that provided scholarships and grant money to students willing to study science and engineering, and teachers willing to teach the subjects, I wouldn't be sitting here. I was working in the field. I was packing corn for ten cents an ear and sorting asparagus for minimum wage, or working in the Sears Home Repair Office as a clerk. I might still be sitting there if I hadn't had the financial aid.

Heffernan: What about the challenges you faced as woman?

Dunbar: I never saw them. I know that sounds hard to believe, and they may have been out there. Many years later I heard about what people said. Either I selectively decided not to hear, or I always looked at it as a challenge. As a child, I read all the time, I learned through biographies that we all face obstacles and people who doubt we can succeed. People who are successful learn to ignore them and stay focused on reaching their goals.

Heffernan: You have a gift for tuning out the cynics.

Dunbar: I didn't lose any sleep over them. It was my life, not theirs!

Heffernan: When did you meet James I. Mueller, your professor at the University of Washington who specialized in ceramic engineering? Why did he matter so much?

Dunbar: Dr. Mueller had a passion for his students—he has since passed away—he was a leader, and he was genuinely interested in students. He loved the fact that graduating seniors would play practical jokes on him.
In fact, I think if the students didn't play a graduating joke on him, he was disappointed.

Heffernan: Were you ever behind one?

Dunbar: No. I mean, I participated in them. But I never led them. I was always pretty benign. But, he was a person who inspired his students to reach as far as they could. And when I told him my freshman year that I really wanted to become involved with NASA and be an astronaut, he didn't laugh. He didn't try and dissuade me. He just promised that I would get to meet NASA engineers if I joined his department. He was true to his word.

Dr. James I. Mueller receives the National Aeronautics and Space Administration Public Service Award. He stands with Senator Scoop Jackson in the Senate Office Building at the nation's capitol in 1981. *University of Washington Libraries, Special Collection Division.*

Heffernan: You earn a Bachelor of Science in Ceramic Engineering in 1971. After you take a job at Boeing, not far from where we sit today, as a systems analyst. Was this your first real job?

Dunbar: My first corporate job. I actually went to graduate school in Illinois for awhile after my bachelor's degree and then came back to work for Boeing for two years.

Heffernan: You were greatly outnumbered by men as you were, really your entire career. Was the gender barrier an issue for you, the good ol' boys club?

Dunbar: No. If you go in with a chip on your shoulder, you're never going to make friends with your colleagues. I just set out do my job."

Heffernan: What did you do?

Dunbar: I originally wanted work in materials engineering. I applied for an engineering position. But Boeing was just coming back after their downturn 'lights out' experience. *(Editor's Note: In 1971, during The Boeing Bust, a sign along I-5 near SeaTac read, "Will the last person leaving Seattle – turn out the lights.")* They weren't ready to put me in that position. Instead, they offered me a position in a new organization called Boeing Computer Services (BCS). Since I had studied Fortran IV programming as an engineer, they knew I could program computers. In those days, computers filled big rooms. The "IBM 360," for example, was the size of a room.

Dunbar has lived through the technological revolution. The IBM 360, a monster of a machine, marked the beginning of Dunbar's corporate career. New to the professional world, Dunbar cut her teeth in computer programming.

They asked me to learn business programming so they sent me to COBOL school in a building just north from the field here. *(Editor's Note: COBOL, **CO**mmon **B**usiness-**O**riented **L**anguage, is one of the oldest high-level computer programming languages).*

Heffernan: What did you make of computer programming?

Dunbar: Anything to do with computers I welcomed. Computers don't have their own minds. We program them. If the computer followed the wrong instructions it's because a human being wrote the wrong instructions.

I like the process of testing your logic. If you want to know whether your process of thinking is correct, write it down and see if a computer can follow it.

Heffernan: You went back to graduate school at the UW and then packed your bags for Harwell Laboratories at Oxford. What an enlightening experience for you! How did it come to be?

Dunbar: My UW adviser in ceramic engineering was Dr. Suren Sarian. We were working on a NASA grant on high energy density electrolytes for solid substrate batteries. I was performing research on a material called sodium beta alumina. Dr. Sarian had taught overseas. He had been at the American University of Cairo at one point. He really believed strongly that after I received my degree, I should take a visiting position overseas for a few months.

Heffernan: Why did he feel so strongly?

Dunbar: Professional development. International exposure. There were only a few places overseas that were actually doing work in the same field. One of them was in Toulouse, France. The other was at Harwell Labs outside of Oxford. And he (Dr. Sarian) had colleagues there. I applied for the position and I was accepted.

Heffernan: What was your impression of your surroundings? What were the people like?

Dunbar: I really enjoyed it. It was not my first trip to the UK. Between Boeing and my master's degree I went back to the UK for the first time to visit my family in Scotland. I was 24 at the time. I'd been to London. I'd been up to Edinburgh. I'd actually been through Oxford and Bath. So I'd been there before. You know, we are not discussing a big cultural revolution. (laughing)

Heffernan: Tell me about Rockwell International Space Division, at Downey, California and your work to protect Space Shuttles as they reenter Earth's atmosphere, the work you started with Dr. Mueller.

Dunbar: Well, actually the reentry capability, and being able to reuse the shuttles due to their exterior coating (which is actually glass fibers) is due to a ceramic thermal protection system.

Every prior vehicle, *Gemini*, *Mercury* and *Apollo*, were one-use vehicles. If you visit them in museums you'll see that the outside is charred. It was covered with a material which was organic-based, and burned away during re-entry. They burn slowly, so they still protect the crew inside. However, because they are burning, they can't be reused. These were called "ablative materials."

In the mid-70's, Dunbar's work helped protect Space Shuttles from excruciating heat as they reenter Earth's atmosphere. During re-entry, temperatures soar to 2300 degrees Fahrenheit. *NASA photo.*

Heffernan: What temperature must the shuttle withstand at re-entry?

Dunbar: 2300 degrees Fahrenheit on the bottom: more at the wing leading edges and nose. It's why you can build a fire in your brick fireplace. Brick is ceramic. However, the thermal protection system has to be lightweight so you can take cargo to and from Earth's orbit. That's why the thermal protection system was made from silica glass fibers. The actual density of the tiles is approximate to Styrofoam. The difference between a brick and Styrofoam – Styrofoam is much lighter for the same size.

(Editor's Note: In 1983, Dr. Dunbar completed her doctorate at the University of Houston "involving the effects of simulated space flight on bone strength

and fracture toughness." She served as adjunct assistant professor in Mechanical Engineering there.)

Heffernan: What do you think you learned from your academic career and your early professional career that's really stayed with you all of these years?

Dunbar: I always went into a position feeling that I was there to learn and to listen to the people who could teach. I always looked at them as teachers and tried to do the very best I could. I put in 110%. When systems fail, I learned why they failed and tried to make it better. But, I also learned that when you think you're right about something, technically, to be able to pull your facts together and to argue your case. You may not always win, but to have the courage to argue your case if you really believe in it. That's important in any type of technical environment. I worked with many really great people.

Keynote Speaker Bonnie Dunbar at the University of Washington Conference on Women in Engineering in 1976. *Reuther Library, Wayne State University photo.*

Heffernan: Who were giving you the confidence to fulfill your dream. When did you next apply for the U.S. Astronaut Corps?

Dunbar: I applied in '77 for the '78 class while I was an engineer working for Rockwell on the *Columbia* Space Shuttle.

Heffernan: So, what does it take to become an astronaut?

Dunbar: NASA published the minimum requirements on its website. You had to have at least a bachelor's degree, advanced degree preferred, in the sciences or engineering. That can include medicine and astronomy, as well as all the engineering branches. Work experience counted and you had to pass the flight physical.

Heffernan: And you made the cut.

Dunbar: I was selected as one of the hundred finalists and went to the NASA Johnson Space Center. It was the Fall of '77 for the '78 class. The '78 class was announced, in January of 1978.

Heffernan: Another example of getting right back on the horse.

Dunbar: Yes. I was not a part of the class. But I was *extremely* honored to become a finalist. There were several thousand who had applied.

Heffernan: And they offered you a job, right?

Dunbar: Yes, later in the year. I was actually traveling back and forth to Houston, as a Rockwell representative for the shuttle. As a contractor, I would brief the NASA managers on how we were doing on thermal protection systems at Palmdale, California. After the 1978 class was announced, they offered me a job in mission control. I accepted the job in July of '78. I was later selected as an astronaut in 1980. We entered a year of what's called "candidacy." And at the end of that year, we received a silver pin and designated as an "astronaut."

Bonnie Dunbar dons a NASA shuttle flight suit in 1981, four years before her maiden voyage to space. *NASA photo.*

Heffernan: You must have been elated.

Dunbar: I was *very* excited to be selected for the '80 class.

Heffernan: And I understand that before you were selected to go on your first mission, you had the opportunity of a lifetime and met the late Walter Cronkite – even joining him for the launch of a Space Shuttle. Didn't he visit your home in Outlook?

Dunbar: Yes. I was part of the on-camera technical support for STS-2 in 1981. Later, he had an evening program in which he would feature different unique stories. I was just one of those programs. He came to our ranch and had dinner with my family. Then, my dad and I were working cattle, so they filmed us on horseback trailing some cattle in the Rattlesnake hills.

Heffernan: What was he like to work with?

Dunbar: He was just a wonderful man.

Heffernan: What an opportunity for you to meet an American icon.

So, at this point, you begin to enter the astronaut's world and train for human space flight. For us outsiders, what does astronaut training really entail?

Dunbar, one of 51 women across the world to launch into orbit, proves early on she has what it takes to live the astronauts' life. *NASA photo.*

Dunbar: Many things. First of all, for every class (and there were 19 in our class) they give us exposure to all technical subjects regardless of our background and experience. So, we received material science lectures from MIT (Massachusetts Institute of Technology) professors, we received oceanographic lectures from Scripps Institute (of Oceanography) in San Diego. We had a week-long geology field trip in Taos, New Mexico. We received lectures on all the engineering systems of the Space Shuttle. We visited the planetarium in downtown Houston to receive our star identification training. There were academics, flying in the T-38, and scuba diving.

Heffernan: Did you become a certified scuba diver?

Dunbar: I was NAUI, certified (National Association of Underwater Instructors) before I arrived at NASA, but I haven't been diving in a very long time.

Heffernan: What about the physical demands?

Dunbar: There's a gym that's available. We have to pass a flight physical every year. So it's really up to the individual to stay fit. It required discipline to stay in shape so we could pass the flight physical every year.

Heffernan: How did you, as an astronaut, learn to respond so quickly under pressure? Is that a skill you acquire in training or an ability you have naturally?

Dunbar in emergency training in 1989. *NASA photo.*

Dunbar: You can learn it. But it is also important to have already acquired a "real time" operations skill and demonstrated it in your prior careers. Most of us didn't graduate immediately from college to become an astronaut. We worked in professions before, sometimes in high-pressure environments or physically hard environments. Those are the types of experiences of things that they evaluated — how you performed when you didn't think you were going to become an astronaut. It also included job performance and evaluations by prior employers.

Heffernan: When do you bond with your crewmates?

The crew bonds during mission training in 1989. STS-32. *NASA photo.*

Dunbar: You bond through training, or before. Crews are professional teams, no different than a submarine crew, an air crew in the military, or an air crew on your commercial airliner, except that we probably train together as a single crew more than any one of those groups.

Heffernan: The space suits look so cumbersome. Do they require training in their own right?

Dunbar: The big white suits are for working outside the spaceship. The orange suits are for launch and entry, weigh less than 40 pounds. You add a parachute to that and they might weigh more than 80 pounds. I don't remember exactly. But you do learn to train in them. It would be similar to


Dunbar climbs Mt. Rainier after her final flight in 1998. *Dunbar personal collection.*

climbing Mt. Rainier. When I climbed Rainier, I had a lot of gear on and you just learn how to walk and function in all of it.

Heffernan: To prepare for flight, you experienced weightlessness. What does it feel like to float in microgravity?


Dress rehearsal for emergency egress from the Space Shuttle for the astronaut. *NASA photo*.

Dunbar: The first time was on the KC-135, which is our parabolic aircraft. The KC-135 started out in the '50s in Dayton, Ohio, Wright-Patterson Air Force Base. It would fly up to 40 parabolas and simulate about 20 seconds of weightlessness at a time. It was used to design equipment to go to space and to study fluid behavior. For example, in a weightless environment, fuels are weightless. So, how do you feed them through to an engine or to a thruster? Specially designed systems are needed. We also evaluated how to get into a 200-pound spacesuit in that environment. So, my first exposure to weightlessness was these 20 second parabolas that we'd fly over the Gulf of Mexico.

Heffernan: What did it feel like?

Dunbar: Oh, that's very hard to explain. The reason we train in water tanks is because if you are wearing a heavy suit, it is neutrally buoyant in the water. If you're a scuba diver, you can swim upside down and around and simulate being "weightless." It's much like that, but much freer because you're not having to wear much scuba equimpent.

Astronaut Dunbar is lowered into a pool at Johnson Space Center. *NASA photo.*

Heffernan: Is it challenging to move around?

Dunbar: No, it's actually a lot easier. The challenge is to not put too much force into your motions.

Heffernan: You were selected for a space flight in October of 1985. How does the actual mission training work? When does the countdown start?

Dunbar: The countdown actually starts when you are assigned to a crew. On the shuttle flight that can be anywhere from 18 months prior to a flight, to a year before the flight. You're training all the way up to launch.

NASA has training teams. They put together a syllabus, a curriculum that's based on years of experience on how long it takes to train an individual to a particular task. The entire training flow is planned. It's not done from week to week or day to day. It's planned with what we call part-task training to full-task training, to integrated simulations. You have to keep up. The bottom line is the training team decides how long it takes to train, and you better train within that period of time.

From a physical point of view, we have to pass that flight physical or several milestones depending on the mission. EVA's, extra-vehicular activity, or space walks, takes more physical training. But we do have a gym that we have available to us. So we tend to work out several times a week and keep cardiovascularly fit.

Extravehicular Activity (EVA) training. According to NASA EVA training is most often associated with spacewalks. *NASA photo.*

Heffernan: Is the training all consuming?

Dunbar: No. There are many things going on, but we do have lives. There's the gym, but that's a small part of your day. There is classroom training, simulations, flying—we fly the T-38 jets to train crew coordination in the flight environment. Depending on the mission, it might be five days a week. Other times, it might be seven days a week for a little while.

Dunbar flew to space five times on various vehicles in the Space Shuttle fleet. Shuttles are reusable spacecraft that carry astronauts and cargo to space. In 2010, NASA plans to stand down its space shuttle fleet. *NASA photo.*

Heffernan: What personal items did you take?

Dunbar: Over the five missions, I've brought a number of small items. They must be approved by NASA. You can't sneak anything on. They must fit within small packages we call Personal Preference Kits, sort of like a little shaving kit. I would take pieces of jewelry for my mother, for example, and a belt buckle for my father. He liked to collect different western belt buckles, which he wore.

Heffernan: Did you keep a diary, a journal, or a mission log?

Dunbar: I didn't, some did. We all took little hand-held recorders up. But you don't get that (much) time to really sit there and keep logs. We have flight plans up there with us that direct what we do throughout the day. We'll make notes on those sometimes. After the mission, we'll reconstruct the mission. They're generally not private notes. The days of taking notes, making logs, are in the space station environment. There is much more time. You

Challenger, second orbiter to join the fleet, carried the first woman into space, Dr. Sally Ride in 1983. Just two years later, Bonnie Dunbar boarded *Challenger* on her maiden spaceflight. STS-61A. *NASA photo.*

actually get maybe a day off at the end of the week where you could sit there and write in your journal, or send emails home. Most of my missions didn't have an email capability.

Heffernan: What major activities led up to your first launch?

Dunbar: After five missions, I don't know that I can remember the first in detail, but I can speak generally. We generally go into quarantine a week before launch.

Heffernan: To prevent sickness?

Dunbar: Yes, to prevent getting colds, for example, and to not take them to orbit.

The countdown clock, in terms of Launch Control Centers, starting about that time. Eventually, they put liquid hydrogen and oxygen in the external tank. They're gradually getting ready for launch. They started the clock. The crew doesn't enter the vehicle until about three or four hours before launch.

Heffernan: What do you see on the Launch Pad when you arrive? I mean, how big is the shuttle itself?

One of the most famous time pieces in the world. *NASA photo.*

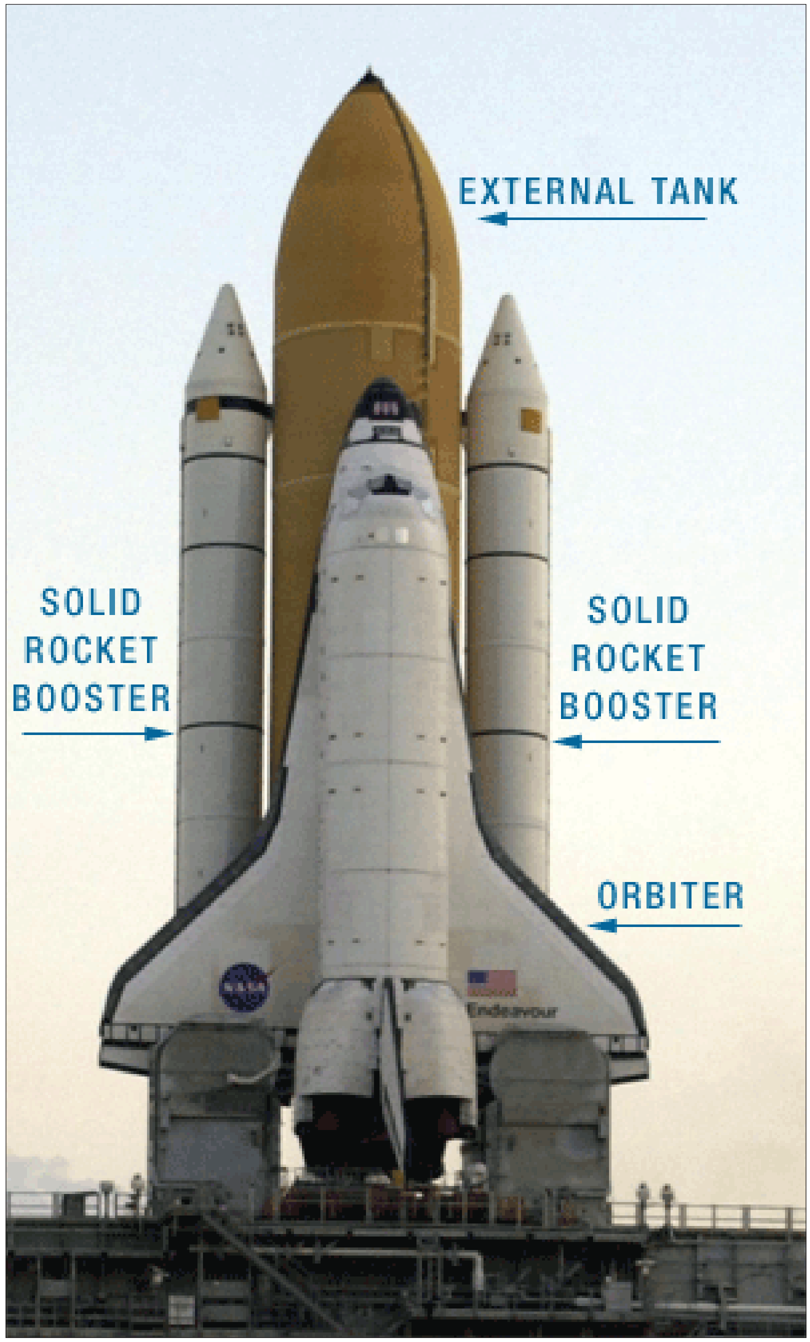
Dunbar: In terms of outside size, it's about the size of a 727. And the interior (the flight deck and the mid deck), is bigger than a 727. It's probably more like a 747 in terms of just the cockpit. When you add a laboratory in the Payload Bay, like a Space Lab or Spacehab, then you're talking about something that's 14 feet in diameter and 20 feet long. It's quite roomy.

Dr. Bonnie Dunbar and crew prepare for launch. STS-89. *NASA photo.*

Heffernan: So, now you're getting close to actual liftoff.

Dunbar: One by one, we enter the vehicle. The crew support personnel are there to help us into our seats, straps us down, make certain that we get our helmet connected, and to ensure that there are microphones appropriately positioned so that we have communication.

Each crew member is checked. Our oxygen is hooked up. Our G-suit is hooked up. Our cooling is hooked up. (laughing) Then they close the hatch. At that point, the engineers perform a pressure check. They over inflate the vehicle to make sure it's at the same delta that we'd see in space, 14.7 PSI. To ensure that there are no leaks, we perform the leak check. There are several different, what they call "launch holds". They're called built-in holds where the clock actually stops but the operations do not.



The Space Shuttle includes the orbiter, two rocket boosters, and a large external tank. Two minutes into the launch, the boosters are cut loose and land in the Atlantic ocean with the help of parachutes. The external tank is jettisoned six minutes later to burn up in Earth's atmosphere. *NASA photo.*

Heffernan: What happens during the holds?

Dunbar: Well, not so much on our part. But at Launch Control at Kennedy Space Center, much is happening. At 30 seconds before launch, if everything looks good, the Launch Control Center then releases control to the Space Shuttle main computers.

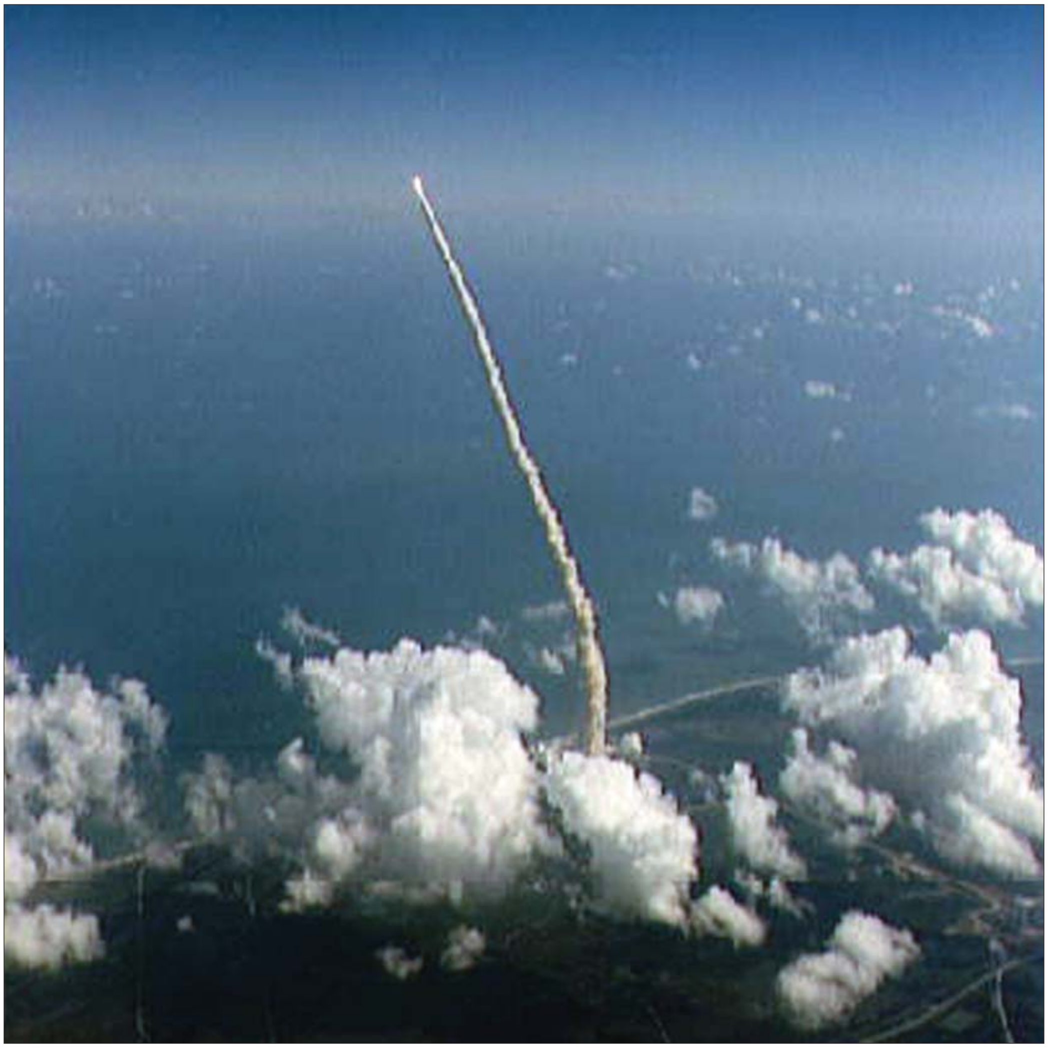
The main engines start. If thrust looks good, then the solid rocket boosters ignite and you're off.

As you start to lift off, acceleration is very low and almost imperceptible, particularly as you're on your back. There is some vibration and rumbling. It comes from the solid rocket boosters (SRB's) and the way they burn. You can hear the crackle if you're on the ground.

Washington native Bonnie Dunbar, on board *Challenger*, lifts off on her maiden spaceflight. It was the day before Halloween, 1985. STS-61A. *NASA photo.*

Once the SRB's drop off after the second minute, and you're just burning hydrogen and oxygen through the external tank in the main engines, it's very, very smooth. But you're not hearing that either. By that time, you're well past the speed of sound. So, the sound is all behind you. The people on the ground are hearing it, but you're not hearing it.

Heffernan: What do you see and feel when you leave Earth's atmosphere?



Washington's only female astronaut soars to space in 1985. STS-61A. *NASA photo.*

Dunbar: Human beings love to draw lines at places, but there is no line in altitude. The atmosphere gradually thins. So you travel from a high density surface at 14.7 psi or 760 millimeters of pressure, and then gradually leave most air molecules behind.

Eventually it is a hard vacuum, but not quite. There are still some random molecules running around up there, what we call "atomic oxygen." But if you were to put your body out there, you'd say it's a hard vacuum. Humans will not survive very long.

However, you do not notice this vacuum inside the spacecraft. You just notice an increase in acceleration. And at one point in the mission, very early on, you reach 3Gs (three times Earth gravitational acceleration). Then the acceleration drops below 3Gs and gradually builds up again. When the main engines cut off, you're back at 3Gs. Suddenly you drop from three times your body weight to zero.

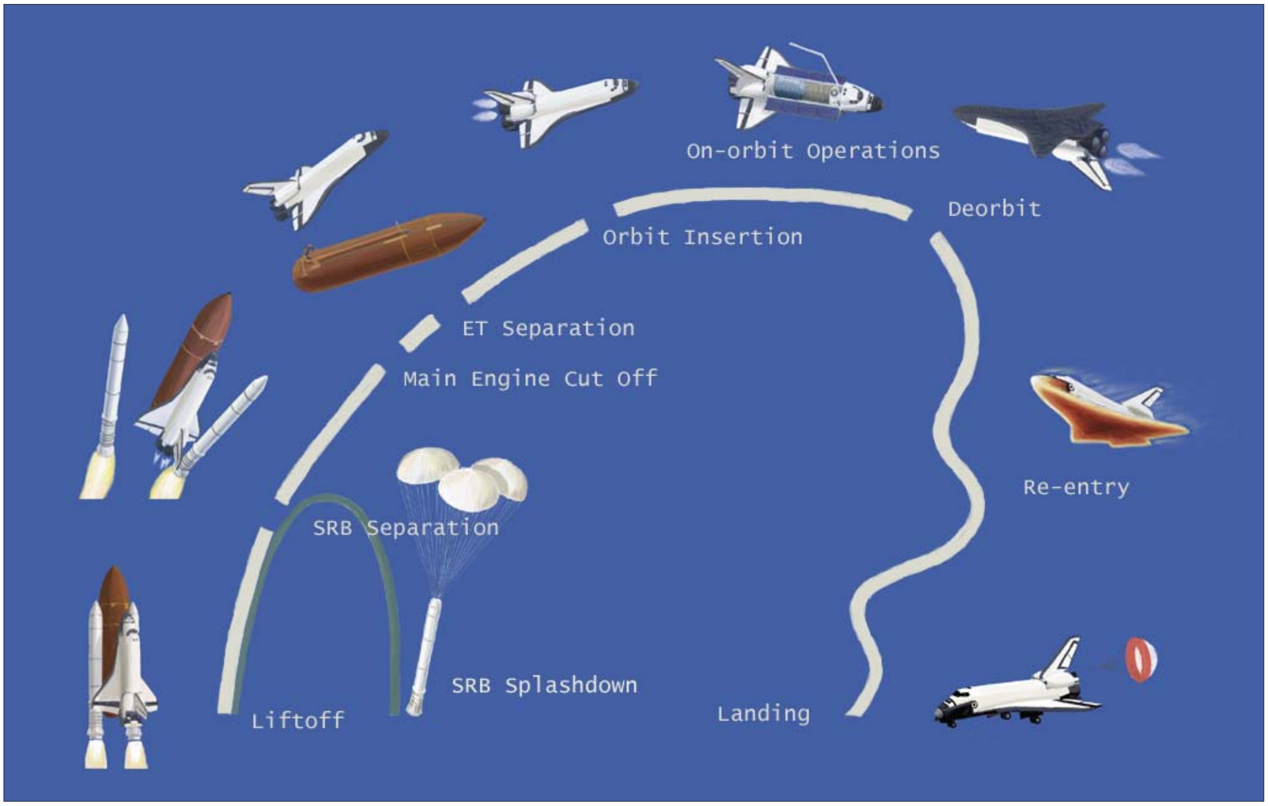
You're immediately in a weightless environment — freefalling around Earth. You're still strapped into your seat, but objects that were held by a tether, start floating around. You can hold a pencil in front of you, let go, and it will float. This checklist that was on a tether connected to a plate on the console for example, starts floating up. It won't float away. It's tethered. But its pages are flapping about as if there was wind. So, you know, you're in a different environment. Then you look out the window and you see a *really* different environment. The Earth is passing below you.

Heffernan: At what point was the external tank jettisoned?

Dunbar: When you reached orbit, after you shut off the main engines. After the first two minutes and six seconds, approximately, we jettison the two solid rocket boosters. We jettison those because they use all of their fuel. The liquid hydrogen and oxygen burns through the three main engines. We continue for about another six minutes on the three main engines. Once we shut the main engines down, we jettison the external tank.

Heffernan: What happens to the boosters and the external tank?

Dunbar: The solid rocket boosters deploy parachutes. They come down into the Atlantic Ocean. They're recovered by boat and reused. The external tank is too high. It typically burns up in Earth's atmosphere.



A diagram of the launch and landing shows NASA's reusable space craft, the Space Shuttle. The rocket boosters and external tank are jettisoned after lift off. NASA photo.

Heffernan: Do you recall your most vivid memory of space during that first flight?

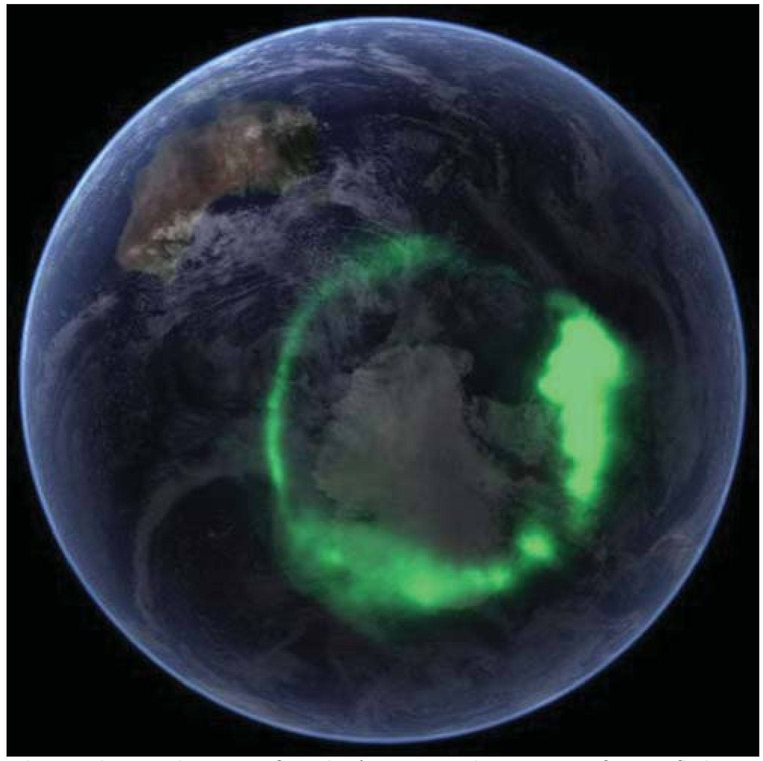
Dunbar: Any view of the Earth is very special. I remember my first flight seeing the Southern Lights over Antarctica over a night pass. It has pulsating colors, including greens, that's quite spectacular. Seeing the islands of the South Pacific, white and aquamarine, that also is quite pretty. There are many spectacular sights.

Heffernan: There are breathtaking images of the Southern Lights. What creates such spectacular color?

Dunbar: Well, the Southern Lights are the South Pole analogy to the Northern Lights. It's the interaction between the Sun and its particles, and the Earth's magnetic pole. That's why you see them at the North Pole and the South

Pole. Solar particles that come from the Sun are focused at the poles. And so that energy, if you will, interacts at the poles.

You see Aurora Borealis at the North Pole and Aurora Australis at the South Pole. If you're on the ground, it looks like a sheet going over you. It looks like the pole is on fire, if you will.



The Southern Lights, one of Dunbar's most vivid memories of space flight, are a stunning sight. Solar wind carries electrical particles from the Sun to Earth's magnetic field creating unforgettable color at Earth's South Pole. *NASA photo.*

Heffernan: Are they as brilliant as the images look?

Dunbar: Oh, yes. Now, some of those images may be a little bit time exposed. But, that's a scene I remember, particularly on my first flight, STS-61A. We had an interesting altitude in the shuttle. We were not tail forward or nose forward, with the Payload Bay toward the Earth. We actually had our long axis tail pointed to the center of Earth. That enables us to put the overhead windows, which are the biggest windows on the shuttle, into the direction you're flying. It was like having a picture glass living room window looking over the Earth in the direction you're flying. And we were flying from light into night near the terminator. I remember the South Pole was on my right and the North Pole was on my left, while we were inclined at 57 degrees to the equator. But I could see the Southern Lights before we actually transferred into daylight, and I could see that, and it was just a really remarkable flight. You float there in front of the overhead windows that are now pointed at the direction you're flying. I thought about being on the deck of the Starship Enterprise, "going where no man or woman has gone before." (laughing) I looked down at this beautiful planet and saw Aurora Australis on my right side. I was heading off into the daylight over some land mass, but I don't remember where. It was pretty remarkable.

Heffernan: We should point out that NASA has all of these images archived on its website (www.nasa.gov). So, your first mission was funded by West Germany and included a crew of five American astronauts, two West Germans, and a Dutch man. You were conducting about 80 experiments?

Dunbar: We used to round it up to about a 100, depending on how you counted it. But, yes.

Dunbar and crew on her first space flight in 1985. She may have been the lone female on the mission but Dunbar never gave the gender barrier much thought. STS-61A. *NASA photo.*

Heffernan: What kind of experiments?

Dunbar: We were in microgravity or weightlessness. So we had physics experiments. We had chemistry experiments. We had life sciences, botany, biology, human physiology, and many more.

Heffernan: How did the conclusions of those experiments help solve real world problems?

Dunbar: You want that answer in thirty seconds, don't you? (smiling)

Heffernan: But ultimately the work helps you get there.

Dunbar: It's like asking, "do you happen to know who Dr. Bardeen was?" *(Editor's Note: the late Dr. John Bardeen twice won the prestigious Nobel Prize in Physics and co-invented the transistor.)* Do you know what electron tunneling is and why it's important to you? I'm not trying to be flippant, but you are asking a really important question. People say, well, unless I can show a cure to cancer tomorrow then this was useless research. In reality it takes time and patience. Sometimes we are trying to answer a question that contributes to the *body* of intellectual knowledge that will help us solve these real world problems.

The problems (experiments) in human physiology, for example, those we were performing on white blood cells, opened up more questions on the immune system. The results actually negated what we thought were the right answers. The work on loss of bone calcium is telling us about osteoporosis in postmenopausal women on Earth because it happens in healthy astronauts, both male and female, in space.

Heffernan: It's a necessary part of the process.

Dunbar: It's a necessary part of the process. Some of them are engineering experiments. "Who designed this spacecraft?" Engineers did. "How did they know how to do it? How did they learn? What did we learn from Apollo that applied to the International Space Station?"

Heffernan: What about this fruit fly nicknamed Smart Willie?

Dunbar: I have no idea who Smart Willie was. Maybe one of the crew members named it. But we had an experiment on STS-61A in 1985 using fruit flies. Fruit flies have been used for decades in experiments in genetic transfers or mutations, because, first of all, they have very short lives. They create multiple generations in a short period of time. So this was an experiment for Germany, very interested in knowing whether weightlessness, over multiple generations, actually genetically would affect vestibular and reproductive responses. So they flew both female and male fruit flies. We would change out their food trays in the glove box. One of those fruit flies apparently got loose. I think was caught and put into a plastic baggie and observed. It was very interesting. A fruit fly cannot fly appropriately in a weightless environment because it needs a gravity vector to do that. So they (fruit flies) would tumble. They of tumbled until they found a surface and then hold on for dear life.

NASA often relies on the fruit flies in orbit to discover and learn about the impact of microgravity on the human body. *University of Wisconsin-Madison photo.*

But what was really interesting was the results of that experiment: they found that in a weightless environment there was some gender differences in how long the fruit flies lived. While I can't remember it exactly, it seems to me that the female fruit flies actually lived longer than the male fruit flies in that experiment.

Heffernan: Why are these experiments so important? Over time, what kind of toll can the environment of space take on the human body?

Dunbar, equipped with a sensor device, prepares to talk to earthbound investigators during a biomedical test on her first mission. STS-61A. *NASA photo.*

Dunbar: It depends how long you're up there. We started flying Skylab in the early 1970s. We flew the longest mission (84 days) and noted seeing that if you didn't exercise, if you weren't taking the right nutrients, you'd actually experience what was called 'disuse osteoporosis' or loss of calcium from the long bones. It simulated postmenopausal osteoporosis in some ways.

(Editor's Note: The country's first space station and orbiting lab, Skylab launched into space back in 1973 atop the massive Saturn V rocket. Astronauts used Skylab to study various materials science, human physiology, astronomy and solar experiments.)

Heffernan: After your first mission, *Challenger* was involved in a fatal accident in which all seven astronauts on board died. I know you want to keep your feelings private and that this is a hard one for you with friends at NASA and a strong sense of duty to mission. But technically speaking, what are the takeaways from that 1986 accident?

Dunbar: The first takeaways are the same takeaways you take away from any accident. The Airbus that just went down over the Atlantic, possibly during a thunderstorm, you learn from it. You learn from automobile accidents. Tragically, most automobile accidents are not engineering failures. They're human failures. We have learned to design automobiles so they don't fail like they used to in the early days. Airplanes are similar — when they go down, we try to separate human error from design error. We can learn from it. We make them better. (It's) the same thing with space flight. You have to look at the fact that the Space Shuttle, was designed for 100 missions. With the *Challenger*, we were only on the 24th or 25th mission *total* out of all the five vehicles we built. It was very early in the test program. In that case, the orbiter, the shuttle itself, did fine. The problem was the SRB booster. There are three main components to what we call the Space Transportation System (STS), the shuttle itself, the external tank (ET) and the two smaller rocket boosters (SRB). We completely redesigned the boosters over the two years we didn't fly.

Heffernan: What did we learn from the *Columbia* accident years later, in 2003, in which the crew and vehicle were lost?

Dunbar: It turned out, as always, it's the little stuff. There was a combination of human error and engineering. But a root cause can also be attributed to declining operating funds from Congress and the Administration which imparted safety practices. If you look at the history of *Challenger* you'll see that it occurred at a time when the agency's budget was being reduced by Congress because we were becoming complacent. There were people being cut out of the flow, (such as) safety engineers and material engineers. The same happened in *Columbia*. The budget for shuttle was being reduced. They were taking safety engineers out of the workforce. They were trying to combine positions. In this case, they tried to install insulation on a connection point between the large external tank and the shuttle. It insulates a cold gas line and it appears that they didn't control the curing conditions of this foam. It fell off during ascent at the worst possible time. It's what you might call a "smart failure." It's very much like the solid rocket booster was on *Challenger*. Both were materials processing problems. The foam fell off at the highest possible velocity, and it hit the leading edge of the wing at the highest radius of curvature, which means it's stressed. It put a hole in the leading edge which wasn't discovered until after the accident.

Heffernan: You returned to space on January 9, 1990 given what seems like the responsibility of a lifetime: to retrieve the Long Duration Exposure Facility (LDEF) that had been orbiting six years in space. The satellite's safe return to Earth had been delayed because of the fatal *Challenger* accident in the '80s.

On Dunbar's second mission (STS-32), she rescued the bus-size satellite LDEF that had been orbiting six years in space. *NASA photo*.

Dunbar: Yes.

Heffernan: How were you selected to perform that task?

Dunbar: I don't know how I was selected. I never asked. (laughing) You


An artist's rendering shows the 50-foot robotic arm Dunbar used to clasp the orbiting satellite. *NASA photo.*

know, I was selected, and I trained, and did it. But I don't know why.

Heffernan: You used a 50-foot robotic arm to reel in the satellite. How did it work?

Dunbar: The robotic arm is called a Remote Manipulator System (RMS), designed by the Canadian Space Agency (CSA). As part of the original design of the shuttle, most shuttle flights had the arm installed. It was designed to retrieve satellites and to perform complex operations. We brought back communication satellites to Earth that had failed in orbit. However, it was actually part of the mission design, to bring LDEF back with a robotic arm. That's how we deployed it. It wasn't deployed on a rocket. We launched it in the Space Shuttle's Payload Bay. We left it there with the intent of bringing it back a lot sooner, to collect data in low Earth orbit — including micrometeoroids impacts, ultra violet light effects, and so forth. Most mission specialists


The satellite as it prepared for a tight squeeze into the Space Shuttle Cargo Bay. STS-32. *NASA photo.*

are trained on the Remote Manipulator System (RMS). That was one of the responsibilities of a mission specialist. It was a great mission.


Noticeably weathered, the Long Duration Exposure Facility (LDEF) remained remarkably intact after six long years in space. *NASA photo.*

Heffernan: There were 200 scientists waiting for the results in *nine* different countries. Were you able to keep it together? Obviously, it was a successful mission.

Dunbar: No, I fell completely apart (smiling). Of *course* we all kept it together. (laughing) If we had fallen apart, it wouldn't have been a successful mission.

Heffernan: But weren't you really feeling the pressure?

Dunbar: Not really. People ask me about these emotions and feelings. Yes, I am always excited before and after. But in the middle of performing, whether you're an athlete or a race car driver or a pilot, you are really focusing on what you're doing. Everything you've done, in terms of training, comes to bear. If you've been in the middle of a final exam, are you thinking about your emotions at that time? You are probably thinking about answering the question on the test.

Heffernan: How do you deal with risk?

Dunbar: You deal with the thought of risk before you launch. You shouldn't be dealing with the thoughts of risk in real time. You are also not the only person dealing with risks. You have got an *entire* team of engineers dealing with risks. You have Mission Control supporting your operations that has dealt with risk. Most risks are well known before we ever launched. My job, however, was to successfully capture LDEF, and to successfully latch it into the Payload Bay.

Heffernan: And what a victory. One of the quotes from Mission Control reported by the Associated Press, "Congratulations, there are a lot of smiling faces down here in the control room, and a lot of happy PI's (Personal Investigators) across the country."

Dunbar: It's a team. I mean, you're giving me a lot of credit but look at the rest of the crew. I would not have been able to capture it if Dan Brandenstein (Mission Commander) had not been able to maneuver the shuttle close enough in exactly the right spot so the arm could reach it. That was key, because you have two bodies now orbiting the Earth at 17,500 miles per hour. And you're closing them very slowly together. So it was Dan who was doing all of the maneuvering of the shuttle, the flying of the shuttle, which made this possible.

Posing for posterity. STS-32. *NASA photo.*

Heffernan: Was there concern that it would be battered because it had been orbiting so long in this environment?

Dunbar: It was supposed to be battered. It stayed in one orientation so it could collect data on the orbital debris environment of low Earth orbit. It had a large number of panels on it so that if there was even a speck of cosmic dust it would collect it. We actually thought that there were marble-sized objects in orbit, maybe there would be more holes. But there wasn't. I think we only found one major impact. So when you talk about battered, it's not like what we might think of battered. It's collecting cosmic dust. It's collecting micrometeoroid damage. We're mapping it to see what that environment is like so that we can build space vehicles and international space stations with enough *protection* so that it isn't affected by that environment.

Heffernan: Where is the Long Duration Exposure Facility today?

Dunbar: It was completely dismantled because the Personal Investigators you were just talking about, received their experiments back. It went to the Langley Research Center in Virginia, where it was completely dismantled and studied. Some of it was subjected to microscopes, some went under x-ray diffractometers to look at structure. (*Editor's Note: Diffractometers are instruments used to identify crystal structures (such as sugar or rock candy) based on their atomic structure.*)

Heffernan: Tell me about your White House visit with President George H.W. Bush and First Lady Barbara Bush.

Dunbar: Our crew also visited President Clinton on a later mission. It's very much an opportunity. After a flight the entire crew is often hosted for a week with their congressmen and women, and then a White House visit. And that was very enjoyable. We had a tour around the White House and we had a


At the White House, Dunbar shakes hands with President George H.W. Bush and First Lady Barbara Bush after successfully nabbing the roaming satellite, LDEF, in 1990.

chance to visit with the president for a while.

Heffernan: What were they like in person?

Dunbar: Very much like you would see them portrayed. Very affable and easy to talk to.

Heffernan: Gracious?

Dunbar: Very gracious.

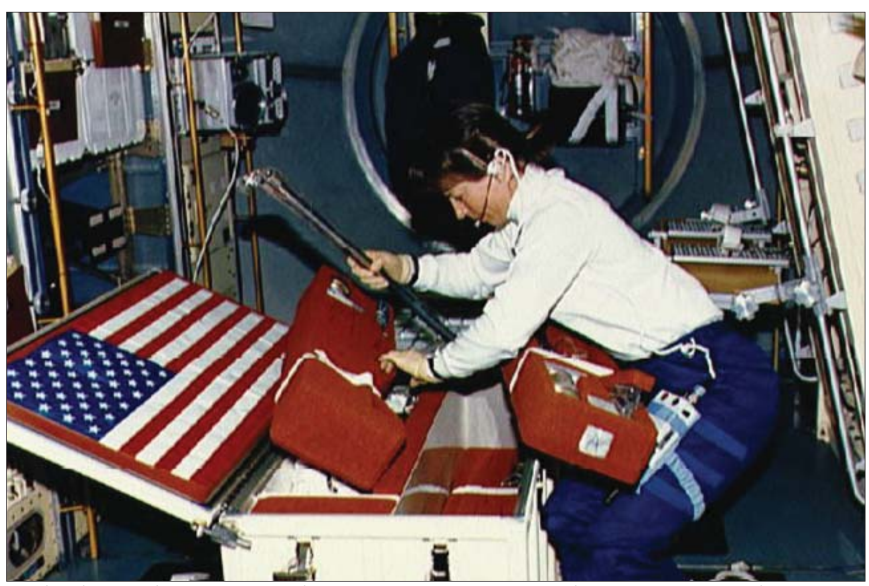
Heffernan: What a well deserved tradition for flight crews.

On your third mission, STS-50 on *Columbia*, your team was credited with helping to launch a new era in space experimentation using the microgravity environment. For the non-scientist, what does space give you in a laboratory that a laboratory on Earth cannot?

Dunbar: There are no zero-gravity rooms on the surface of the Earth. g, as you know, is gravity. You are (on Earth) in one g, right? And the Moon is how many g's? One-sixth. And how many g's on Mars? One-third. Okay. So, what causes hot air to go up and cold air to come down? What causes a hot air balloon to go up? Well, when you heat hot air up it gets lighter and cold air comes down. That happens because of gravity driving convection.

Without gravity that whole dynamic of convection doesn't happen. Convection happens in liquids when you're trying to grow crystals too. And if you write the equation of fluid physics on how you grow a crystal, you'll find "g" in most of the equations. Now, take "g" out of the equation, and what happens? What we found in going to a weightless environment is that we can grow crystals differently, whether they're for electronics, or (they're) protein crystals that (help us) design drugs to treat diseases. You have to grow the crystal first, and then you subject it to x-rays to look at the structure, and then you design the drug. It's called rational drug design. And *a lot* of these crystals simply wouldn't grow on Earth's gravity, they would start to grow as a crystal and then gravity would deform them, change their shape, resulting in the wrong crystalline data structure. But in a weightless in environment—where it's freefall—proteins would grow into more perfect crystals. Once the crystal was grown, we could bring it down and do x-ray diffraction on the Earth. So, the pharmaceutical companies would actually patent structure in designing the drugs. That

Mission Specialist Bonnie Dunbar conducts a crystal growth experiment. STS-50. *NASA photo*.



Payload Specialist Bonnie Dunbar in a U.S. Microgravity Lab. STS-50. *NASA photo.*

was just one example. We took many experiments which were affected by gravity and repeated them in orbit. Now in this laboratory in orbit, the International Space Station (ISS), is up there constantly—you can do research up there on the human body, on botany, on biology, on crystal growth, and many other disciplines you *couldn't* do here on the Earth.

Heffernan: Some of the research could have assisted with AIDS, cancer, emphysema, and heart disease.

Dunbar: That's the protein crystal growth, yes.

Heffernan: Quite a reach.

Dunbar: The other part of this is that it has an exploration impact as well because we did a lot of work on the human body. We know how the body functions in one g because we're here on Earth. But we're learning more on how it functions on zero gravity. We also need to know how it functions in one-sixth g and one-third g if we're going to continue exploring. So we need both sides of that. It also adds to our scientific body here on the surface of the Earth. It's already had impacts in medicine, in crystal growth, in botany and biology, and genetics. And now it's having an even bigger impact on exploration of the human species.

Heffernan: What do you make of the American preoccupation with the astronaut's daily living environment in space– while you're working so hard to solve real world problems? "How do you wash your hair in space? How do you eat?"

Dunbar: Going into space is an experience that has many aspects to it. People are very interested in things they're most familiar with. One of the


Mission Commander Richard Richards and Payload Commander Bonnie Dunbar enjoy a meal on the mid-deck of the Columbia in 1992. STS-50. *NASA photo.*

other things I noticed is that kids will ask questions about anything. However, adults are embarrassed to ask questions about some topics. I answer most questions. If in answering that question you can help stimulate a discussion we're having about the difference between one gravity and zero gravity, and if that even sparks a little bit of understanding on the science and engineering of it, then that's helpful. So, why does water not drip from your hair up there when you're washing it? Why does it create a sphere? That's a new environment. And yes I'm applying it to my hair, *but* it has a whole field of applications in science.

Heffernan: Because it resonates. They connect with you.

Dunbar: They connect with that part of it.

Heffernan: You were backup for Norman Thagard, first American to ride a Russian rocket into space as he prepared to make history. You trained in Star City, near Moscow after the glory days of the Russian Space Program. Do you remember what you saw when you arrived?

Dunbar: Star City, of course, the Gagarin Cosmonaut Training Center, was established with Yuri Gagarin as its first head to train cosmonauts. Not only Russian cosmonauts, but the Soviet Union had always had a very active

Dunbar signs the Gagarin Space Flight Log with Cosmonaut Commander Anatoly Solovyev. *Dunbar personal collection.*

invitational program to other countries, just as we did. My first trip there was in 1991, when I was part of a delegation for the American Institute of Astronautics and Aeronautics. We were in a technical conference in Moscow and then flew down to Tashkent, to the Academy of Sciences. The Gagarin Cosmonaut Training Center was still very active, and showed very little wear and tear.

When we returned in ’94, of course, the country, the nation had transitioned and the Iron Curtain had fallen. Economically the country was strained, and you could tell. In Moscow, there were few fresh foods on the store shelves, for example, in the middle of winter. We could see some of the infrastructure wearing, aging, at Star City as well.

Heffernan: You were completely immersed in another culture and learning Russian for the first time, while you prepared for flight.

Dunbar: I’d actually been taking Russian lessons before I went to Russia. But I hadn’t been speaking it. I was in a class.

Heffernan: You’re quoted in an article about life in Star City saying, “It’s like being in first grade and grad school at the same time.”

Dunbar: Yes.

Dunbar trains in Star City on the Russian Rocket *Soyuz* with cosmonaut crew. *Dunbar personal collection.*

Heffernan: What was the training like?

Dunbar: Well *all* of your training is being delivered in Russian. It's all technical. So you're still learning the language, how to speak it, but you're also expected to grasp *all* of the technical concepts.

Heffernan: Did you have confidence in the program?

Dunbar: Yes. It's like any flying environment. They were maintaining a space station and flying back and forth to it. It was different training, a different approach than we have, but we were training together, and we had a successful program.


Dunbar roughs it with cosmonauts while immersed in survival training near Star City to back up Dr. Norman Thagard, first American to ride a Russian rocket to space. *Photo from Col. Terrence Wilcutt.*

Heffernan: Were you indifferent on being the backup for Dr. Thagard? Did you wish that you were going after putting your heart into this?

Dunbar: No. I went over there to be a backup. That was my job. It wasn't just to train to back Norm up. We were the first two astronauts over there since *Apollo*. So it was my job to learn as much as I could. I wanted to be able to return (to the U.S.) and help the next crew be more prepared.

Astronauts Norman Thagard and Bonnie Dunbar at the Gagarin Cosmonaut Training Center. *NASA photo.*

Heffernan: Can you compare his launch into space to a launch in the United States?

Dunbar: The Russians do not launch out of Moscow or Russia. They launch out of Kazakhstan and in Baikonur. How would you compare the differences? Different rockets, different fuels, different launch operations. Our launches are primarily civilian managed, but on ranges that used to be managed by the Air Force. The Russians still are primarily managed through their military. So you'll see military officers at the launch site. So, different systems and different ways of doing business.

Heffernan: Were you a prouder American upon returning?

Dunbar: I've always been a proud American. I went over there and made friends, I made a lot of good Russian friends. People are separate from their governments in most cases, so I made good Russian friends.

Heffernan: Do you still keep in contact with some of your Russian friends?

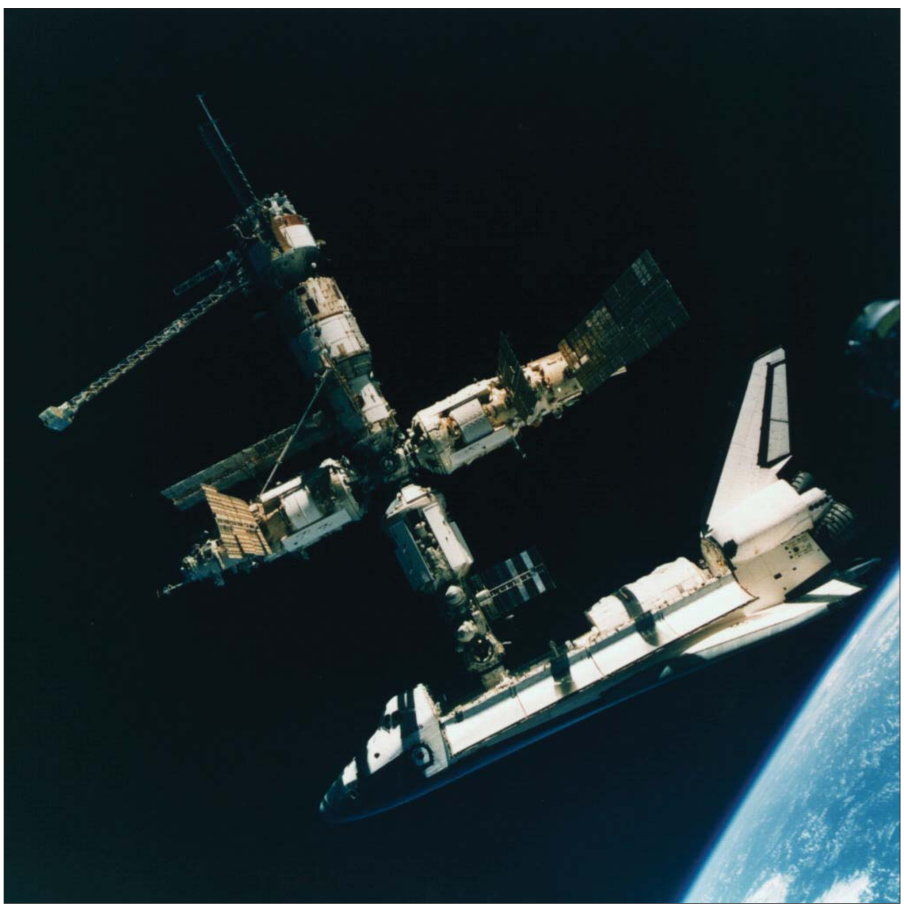
Dunbar: The cosmonauts, yes. But the people that I met in Star City, it's harder. Star City is still a military base.

Heffernan: Are you still fluent in Russian today?

Dunbar: No. (laughing) Oh, I could say a few words, but I'm not fluent.

Heffernan: Your next mission, with the cosmonauts, was quite historic – the first to dock with space station *Mir* and the first international docking in 20 years. Can you walk us through it? It boggles the mind. I mean you were orbiting at speeds of 17,500 miles per hour. How did those speeds change as you approached *Mir*? How did the docking actually work?

Dunbar: The speeds don't really change. You're both orbiting at 17,500 miles per hour; that's the really important thing to remember. Your orbital speed is driven by the altitude that you're at; that's one of Kepler's laws. And so, really what you're doing is as you catch up to the *Mir* by having a lower orbit which causes you to travel a little faster, finally you work your way up to the orbit of *Mir*. The Commander generally flies the docking, again having



In 1995, Dunbar sails to space on board *Atlantis* for an historic docking with *Mir*, the Russian Space Station. In this photograph, *Atlantis* docks with *Mir* while this picture is taken from a third spacecraft, the Russian Rocket *Soyuz*. STS-71.   *NASA photo.*

to obey the laws of orbital mechanics, it's a very careful operation. We train quite a bit for it.

Heffernan: Was there a greater sense of making history during that particular mission?

Dunbar: I never think about making history while I am there. If you're doing that, you're not putting all your brain cells where they need to be. (laughing) It was very successful. You know, this was the first time the shuttle had ever docked to *Mir*, and (it required) a lot of training. The fact that it happened (on) the first try I think was pretty significant.

Heffernan: There was a ceremony broadcast from the core modular of *Mir*.


Signaling a new era, astronauts and cosmonauts pose together in space. STS-71. *NASA photo.*

Dunbar: That was tradition. We did that every docking mission. When we opened the hatch we had a handshake at the hatch, and then the crews went back to the "base block" of the *Mir*, which is larger so it could accommodate all of us. And usually, the flags were up, both the American and Russian flags. We exchanged gifts and we had a joint press conference. In our case, both were broadcast to Russia and the United States.

Heffernan: How did the press conference work?

Dunbar: It was mostly one way. We broadcast to the ground and we spoke. We may have had press ask questions but I don't remember that.

Heffernan: Do you remember the first words that were spoken once you docked?

Dunbar: No, I do not. (laughing)

Heffernan: What medical experiments took place on the flight?

Dunbar: Oh, a multitude. You're talking about the first docking. We had a lower body negative pressure device there to look at the changes in the cardiovascular system. We had EKGs as well, echocardiograph looking at heart volume and blood flow. We were looking at the cardiopulmonary system. All the changes in the physiological system, including blood chemistry. We took blood samples as well.

Dunbar undergoes a medical experiment. STS-32. *NASA photo.*

We had the European Space Lab in the Payload Bay, to do medical experiments on the crew that had been up there, including Norm, for 90 days. Because we knew, once we returned into one g (Earth gravity), some of the changes that had occurred to them from a human physiology point of view might be reversing. So, I trained for the three months while they were up there on (how to) conduct those experiments, as did the other two mission specialists who were on the flight. So, we were very busy during those five docked days performing experiments.

Heffernan: What were the main objectives of your final flight on board *Endeavour*?

Dunbar: We delivered the eighth crew member to the *Mir*. On my fourth mission we picked up Norm and his colleagues, and then we dropped off two Russians that I had trained with on the backup crew Anatoly (Anatoly Yakovlevich Solovyev, former cosmonaut and pilot) and Nikolai (Russian cosmonaut Nikolai Mikhailovich Budarin). On STS-89 we dropped off the eighth crew member, Andy Thomas, and we picked up Dave Wolf. We had a large number of science experiments we transferred over, and about a couple thousand pounds of cargo. We brought an equal amount back.

Heffernan: Can you outline your specific duties?

Endeavour, the machine that replaced Challenger, carried Dunbar into orbit on her final mission. The flight is widely considered the most successful visit to the Russian outpost *Mir*. STS-89. *NASA photo.*

Dunbar: I was Payload Commander on that mission. I had been Payload Commander on my third flight as well. It was my job to choreograph activities on orbit, all the way from training to execution.

With the crew before the launch of *Endeavour* in 1998. STS-89. *NASA photo.*
Astronaut Mike Anderson, shown on right, considered Washington State his home. Anderson and the *Columbia* crew died in 2003, just 16 minutes prior to the Space Shuttle's scheduled landing.

Heffernan: I read in the flight highlights there was a problem with Andy Thomas' (Australian-born astronaut) pressurized suit.

Dunbar: It wasn't so much a problem with the suit. One of the things that happens when you get to orbit is that your spinal column extends. It grows because you don't have gravity compressing it. When they make the suits for you, they try to accommodate that growth because he's going to come back in the *Soyuz* (Russian rocket). When we get up to orbit, the first thing you do is try it on to make sure it fits. It was a little bit tight on Andy. But he was able to get it on. And maybe because his spinal column grew a little bit more than expected.

Heffernan: After your final mission you started a new chapter at NASA as Acting Deputy Director of Flight Crew Operations.

Dunbar: At that time, Flight Crew Operations was in charge of the Astronaut Office and all flight operations at Ellington Field. That's where we had our T-38 jets, our shuttle training aircraft, our KC-135, and our WB-57 high altitude research airplanes, and the Super Guppy. I think those are the major aircraft we had. It includes hangers and instructor pilots. It wasn't just about training for flights. I was also supporting technical committees and technical operation committees that are across Johnson Space Center, whether it was preparing for existent missions or preparing for future missions, such as building the International Space Station or returning to the Moon.

Heffernan: Did you enjoy the work?

Dunbar: Oh yes, I did. After my last flight, I received my certification for Senior Executive Service (SES). I had my five flights, which was kind of the magic number then. I was asked to transition into management and I did.

Heffernan: What do you mean five flights is kind of the magic number?

Dunbar: There were so many astronauts and so few flights. So it wasn't official, but if you had five flights, that's kind of the magic number.

Heffernan: You'd had a wonderful opportunity.

Dunbar: Yes.

Heffernan: Can you describe your work on space suits and the sizing problem for females?

Dunbar: There still is a sizing problem for some of the females. It's driven by economics more than anything. Back during *Gemini, Mercury*, and *Apollo,* the (astronauts) wore custom suits. It didn't matter how long your arms were or how tall you were. They customized the suits so you could function in them. When we started the shuttle program, they decided so many more astronauts were going to fly it would be economical to build suits that had interchangeable arms and lower waists. Lower torsos, they called them, hard upper torsos, gloves etc. And so they decided there were to be five sizes of what they called the "hard upper torso." They would fit crew members from a fifth percentile Japanese female to a ninety-fifth percentile Caucasian male. That's a pretty big range. There's no such thing as a standard person. If you're a standard fifth percentile in height, you're probably not fifth percentile in arm length, or in your waist, torso length. It really started to become hard just to fit people. I was a contingency EVA (Extravehicular Activity) crewmember for my first two flights.

Dunbar trains for space in 1990. *NASA photo.*

On my first flight, I flew a medium suit. There was extra-small, small, medium, large, and extra-large. And I'm in about the seventy-fifth percentile height for a Caucasian female, which means about the same as an average Japanese male. I had a pretty good suit fit. The upper torso was maybe a little roomy, but I was able to work in it.

Then *Challenger* happened and there were budget cuts. I'd already been assigned as an EVA crewmember on my second flight. I went in to get into my suit, and they said, "Well, we forgot to certify your configuration. You're going to have to get into a small hard upper torso." So, I got in this thing in the first run in the water tank and could hardly breathe because it was small. And the other was the arms were too long; my fingers didn't reach the end of the gloves. So I said, "Well, you know this is going to be a little hard because I couldn't function underwater." And they said, "Well, we don't have enough money to change it."

Heffernan: So, does an inch here and there affect the safety of the astronaut?

Dunbar: It could but it was not so much the safety of the astronaut, it was also mission safety. You're in a big balloon. You need to be able to function. It's like putting on your father's gloves and being asked to do brain surgery.

Heffernan: Even if you're saving money by mass producing the suits, you're losing it in terms of mission success.

Dunbar: Right. But these decisions were being made in Washington D.C. while the training is happening in Houston. Your suit tech and trainer are not in the position of changing the budget. So, I was a contingency EVA crewmember. That meant that *only* if we had a problem on the shuttle, did we have to do a spacewalk. They had decided that in the interest of the budget they'd only make suit modifications if you really were going to do a *planned* EVA. Well, *fortunately* Kathy Thornton was on one of the *Hubble Telescope* missions. She was slightly smaller than me but she also needed shorter arms. So they made some custom arms for her and they fit me fine. So I trained in her arms. But they weren't going to manufacture them for me. There also was no one on my crew that could take my place. David Low and I were the two EVA crewmembers. After we returned, we debriefed with Mr. Abbey (George Abbey) who was head of the Johnson Space Center, and he was really quite surprised. We conducted a study and determined that, with a shrinking budget, reducing suit sizes at the small end would start to impact the number of women who could fly on each crew because you always had to have two crew members on every flight who can do an EVA. We had 20-plus percent females in the astronaut office, most of them mission specialists. This suit decision was affecting a big proportion of them, about 75 percent.

Unfortunately, the bean counters in Washington D.C. were not convinced. I believe we're starting to see the affects of it. Fewer and fewer women are flying because we don't have enough EVA suit sizes. Now, I personally cannot wait until the Chinese start performing EVA's because I'm exactly the height of the tallest Chinese astronaut. If they're making suits to fit, perhaps we can buy them from the Chinese.

Heffernan: Does this mean you may fly again?

Dunbar: No, it just means that I will say, "Okay, if the Chinese know how to build suits that fit their astronauts, or taikonauts, who are a maximum of my height, then they may know how to engineer them for all women. Perhaps we can buy the suits from them."

Heffernan: Who are the unsung heroes at NASA?

Dunbar: Hundreds and *thousands* of people are unsung heroes. Going back to the time when NASA included space in its name, the National Aeronautics and Space Administration of 1958. We would have never have reached the moon without these hundreds of thousands of unsung heroes. And they're everyone from the people in the office who managed your letters and your phone calls, to the engineer out on the floor, to the manager or administrator trying to get funds for exploration from Congress. They are all unsung heroes.

Heffernan: After seven years in executive management and five trips to space, why did you decide to retire from NASA? Was it a difficult decision for you?

Dunbar: There are a lot of reasons. First of all, I was there 27 years. I had been in management for almost seven years. I knew that at some point I'd be going on to another, fourth career, if you will. It was a matter of opportunities. This opportunity came up. I was very interested in our educational STEM (Science, Technology, Engineering, Mathematics) and very concerned that we're not going to have the scientists and engineers that will take us back to the Moon and on to Mars, or to continue exploring.

I didn't want to see us go the way of civilizations that have, as recorded in history for the last 8,000 years, became complacent. They decided not to invest in research and technology, and not to explore. Therefore, they've been lost to the history of the world. And if you look at all those nations, you'll see that the investment in science and technology is critical. So I wanted to be part of the pipeline here (at the Museum of Flight) in inspiring adults and youth. We need the understanding of what it takes to build that history, to love science and math, and to build the future.

Heffernan: Declining interest in these fields of science and math is not a new problem, in your mind.

Dunbar: I have to tell you. I've sat on panels for a decade now. We know what the problem is, we just rehash the problem. One of the reasons I'm here is I hope that we can be a part of the solution now. Is that how do we inspire our youth to love science and math in the third grade?

Heffernan: So, what is the solution, in your mind?

Dunbar: There is no one magic bullet. First our academic standards: we don't expect enough out of our kids. When I do go back to Scotland, I find that every fifth grader is starting algebra. And that's in all schools. Why are we waiting so long? And why do we think it's so hard? And why do we tell students it's so hard?

Heffernan: We're setting them up for failure.

Dunbar: We're not only setting them up for failure, we're setting our nation up for failure. We're risking our nation if we don't have scientists and engineers – the infrastructure of the nation. Where are the engines of the economy? Where are the solutions to the environmental problems, the energy problems? Those are scientists and engineers. It's not just about appropriating the money out of your government. It's what do you do with it.

Heffernan: What else?

Dunbar: Teach the teachers. We have a shortage of math and science teachers. We force teachers to teach that subject and they don't understand how it's applied. Sometimes they don't have the passion. Is that their fault? Probably not. It's our fault. We're not helping the teachers through the programs so they can help the students. By being turned off themselves, they turn the students off. I don't know how many kids will tell you, "Well, my teacher can't tell me what an engineer is." Or I've had teachers tell me, "We don't tell our kids to become engineers because we want them to learn how to work with other people." And I look at them and I think, "I am an engineer. I spend most of my time — have spent most of my time – working with other people." So, it's an understanding. In some cultures, engineers are respected as the engines behind civilizations. The pyramids were not materialized out of ether. They were built by engineers and mathematicians. Navigation came from astronomers and the stars, and the mathematics that came along with that.

It's about high expectations and standards. It's teaching the teachers. It's educating the parents and the influence they have on the kids. I once went to a reception in Houston while I was a manager for NASA, a Christmas reception. I walked in the door and was introduced to a woman who told me very proudly that her son was going to Texas A&M. Then she went on to say that she hoped he didn't get influenced to go into engineering.

Heffernan: What was her reasoning?

Dunbar: She wanted him to be creative, wanted him to learn how to work with other people—many misconceptions. Look at *Fortune 500* and the number of CEO's that have a technical background. There's quite a few. Who exactly received the patent to build a new device? It was not the accountant. (laughing) So, there's a societal educational part of the solution. We vote these days on science issues. What frightens me is that we don't always have an electorate that understands the science issue. And so are they making the right decisions? The media is just as culpable. It used to be when I watched Mr. Wizard, Mr. Wizard was in the classroom, in the laboratory, with little boys and little girls. It was normal. I *loved* physics, and I was also a cheerleader, and I was on debate team. There was no line drawn between those two.

Irene Peden, 1973 Society of Women Engineers Achievement Award recipient, and Bonnie Dunbar enjoy a conversation in 1980. *Reuther Library, Wayne State University photo.*

Heffernan: And now there's a line and you think engineers aren't viewed as normal?

Dunbar: Well, where did the word nerd come from? Little girls who study and love math, when they are old enough to date, don't want to admit it because they don't want the guys to think that they are either smarter than

Bonnie and Bobby Dunbar grow up on the cattle ranch in the Yakima Valley.
Dunbar personal collection.

they are or too "nerdy." And where do they get that? Saturday morning TV? My sister's a teacher, by the way, and she graduated from Pullman, so we talk about these things. So the media has to give more positive images and storylines that have real engineers in them solving real problems. Maybe it's the environment. Maybe it's energy. Maybe it's transportation. So the media is part of it as well.

I was able to go to the University of Washington and become an engineer because of the National Defense Education Act. My family couldn't afford college. And all the scholarships I could try to garner couldn't send me to college. But the National Defense Education Act was put in place by presidents Eisenhower and Kennedy to educate an *entirely* new generation to take us to the Moon. That was a big peak of scientists and engineers, and we're still living off of that. But that financial aid was part of it. It also paid for students to become teachers of science and math. So, you fix that other part of the problem. So it's all of those things together. And we *all* have a part to play in it.

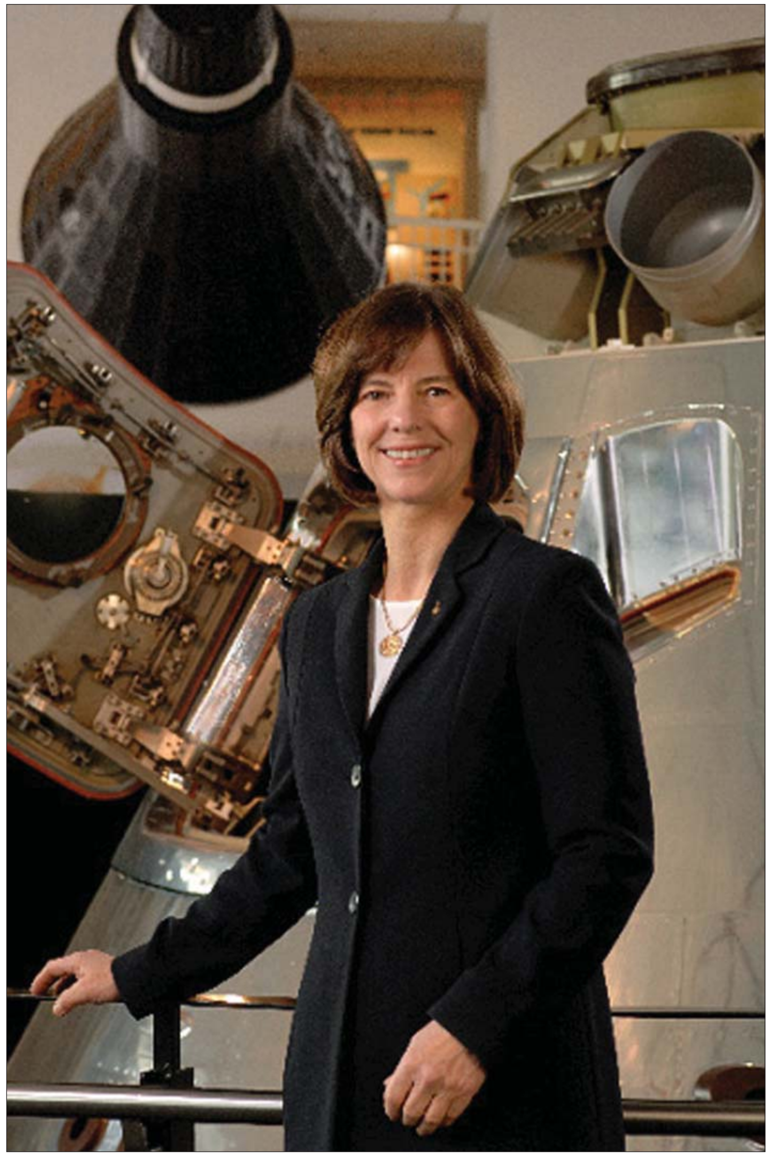
Heffernan: You're so passionate about this 4^{th} career and look what you've already accomplished.

Dunbar: Why wouldn't I be? People need to be doing the things that they're passionate about. We should look at education, or the opportunity to read and be educated as a gift. There are people around this planet that don't have that gift, don't even have a book, don't know how to read. Once we know how to read, and we understand—what we're doing is transferring several thousand years of civilization in a small period of time to someone's brain. That forms a foundation to go forward. We must be an educated population if we're going to make the right decisions with the right information based on the right understanding of science and engineering.

Heffernan: What are you doing at the museum to generate student interest in the fields of science and engineering?

Dunbar: We first excite them. Flight has many components. It's not just a flying machine. It may be the pilot, the engineer, if you're flying in jets you have a helmet and that has oxygen. Why? You have to understand the human physiology. We have what's called a rotating chair to teach how the vestibular system works. All those topics relate to flight. Once you see that spark in a kid's eye, you've got them hooked. Then they're asking you the question, "Why?" We put them into the classroom with a plane and they learn that there is 360 degrees in a circle, and north is here, and south is here, and how to navigate. How do I calculate the time from point A to point B if I'm flying 120 miles an hour? They've now suddenly learned geometry, and they've learned algebra, and nobody told them those were the topics, and that they should not like them. So, what we're doing, through all 12 grades, (the programs span all 12 grades), is teaching them to be excited about it, how to use math and science. We teach them what subjects to study in high school, which will allow them to be part of that pipeline to engineering.

Our Washington Aerospace Scholars Program, which includes 160 juniors from throughout the state every year, is a good example. We track them to see how many go into engineering and science. We measure how our programs may have influenced them. We do continual assessment to see how we can improve it. What we're trying to do is fix that part of the pipeline—the inspiration part of it. I call it connecting the dots: why do I need math and science?



Dunbar begins a new chapter leading Seattle's Museum of Flight. *Museum of Flight photo.*

Heffernan: It must be rewarding when that light bulb comes on and you're connecting with a child. Or, a child is standing in front of an exhibit being exposed to a *brand new* world, *brand new* subject matter, that's wonderful.

Dunbar: Well, it is any time you can help teach. It doesn't have to be a child. If I could somehow teach you the laws of fluid physics, and your eyes lit up about why g was important, I would have felt good about that.

Heffernan: It's a good day for you and for me.

Dunbar: It's a good day. It helps people understand, "Why do I have a space station up there?" That is the only place that laboratory can exist. Why is it international? Because all those nations understand that's the only place that lab can exist, and we've banded together. So we have a *common* power supply, the solar rays, a *common* communication system. All our laboratories are different but they're all connected, and with the same goals to help us learn more about science on Earth and to develop the tools to explore beyond Earth.

Heffernan: And is this new passion, your fourth career all you'd hoped?

Dunbar: It wasn't a surprise to me because I had been speaking at this museum since 1987 and had been on the board since 2002. So, I knew the people here, had always admired the museum, loved their educational programs or I wouldn't have become involved in it. The agreement I made with the Board of Trustees was to grow education, and to be a part of the interest in STEM careers: science, technology, engineering and math.

Heffernan: This entire effort, leading a new generation to the STEM careers, why is it so important? Why must America lead in the area of space exploration?

Dunbar: Because history shows us, and you can see this here at the museum (Museum of Flight), when you invest in technology and lead, it translates right back into the quality of life for every American, and their influence in the geopolitical environment.

Many people in Third World countries look at your quality of life and relate it to your political infrastructure. It's the same thing, you know.

The Russians were trying to do exactly the same thing under the Soviet Union. I think people inherently value their opportunity to make choices for themselves.

My Russian instructor at Star City said that when he was in middle school, a man came into the classroom and divided them into thirds. He said, "This third will learn to teach French. This third will learn to teach Russian. And this third will learn to teach English." And he was in the third that learned to teach English, and teach Russian to English speakers. He had no choice.

We're enjoying a wonderful life right now and we're taking it for granted. If we were sitting in a third world country right now, would we be debating it as to whether we want to lead or follow? I don't think the question now is even do we want to lead, it's do we want to play? We're standing down our Space Shuttle Program to debate whether or not we're going to build a new vehicle to go back to the Moon and on to Mars while four other nations are planning to explore beyond Earth orbit. This is the 21st Century and we should continue to lead. Nations are not leaders forever. They become leaders when their populous decides to invest in education, in research and development, and in new technology, whether it was the sailing ships of 200 years ago or the spaceships of the last century.

I think it returns us to a fundamental question – are we a space-faring nation or are we not? If you're saying no, then let the Sun set on our civilization. We'll sit back and be a nation of watchers and not doers. Our quality of life will not quite be the same and we could even become another

Third World country. But if the answer is yes, you have to ask yourself how do we move forward? We invest in education. We invest in research. We invest in technology. Crucially, we need the courage to try. Since its inception, our nation has benefitted greatly from people who found the courage to lead. Sometimes, you fail. You can't be afraid of failure. You have to take risks. But in the process, you design new systems, new businesses, and new economies. And therefore, you keep your leadership position.

NASA photo.

Heffernan: The country needs to make the investment.

Dunbar: It's not a given. It doesn't happen accidentally. When we went to the Moon, it was a leadership-driven initiative supported by Congress and the American people. If we go back to the Moon and go on to Mars, it will have to be under the same circumstances. But if we sit back and wait for it to happen, it won't happen.

There is a speech given by President Kennedy at Rice University Stadium directing us to the Moon. It's *electric*. He committed this nation to going to the Moon in ten years or less. "Not because it's easy, but because

President Kennedy, at Rice Stadium in 1962, prepares the nation for the lunar landing. "It doesn't happen accidentally," says Dunbar of the country's bold initiative. *NASA photo.*

it's hard." He said, "because *this* mission will serve to organize the nation, and to push us to our best. To invest in educational facilities, and capabilities, and research labs, and it did.

We are still living off of *Apollo*. You have computers and microprocessors. Go back to *Apollo* for that. And I brought up Dr. Bardeen, who won the Nobel Prize, because his very confusing title of his research project led to the transistor. Most people didn't understand the title or the nature of the research, but if we didn't have the transistor you'd be putting big vacuum tubes in some big box you'd carry around. (laughing)

Heffernan: Do you feel that the space community as a whole can better deliver a message that what is happening in orbit is relevant to the real world?

Dunbar: I don't think that's the problem. People take technology and science for granted. They've got their cell phones. They can text. They've got refrigerators. They've got air conditioning, heat, and preserved food. They have communications, transportation, and most people have a roof over their heads, but they don't realize how it came to be, or the role of science and math. If the parents don't understand, it's very hard for them to communicate to their children. If the teachers don't understand they can't engender that excitement of discovery and creation. Engineering and science are very creative disciplines.

Heffernan: What's next for Bonnie Dunbar?

Dunbar: I go one day at a time. Here, we have a vision for the museum. We want to build a space gallery because we're applying for the Space Shuttle and we want to build a cover for all our outdoor airplanes.

Heffernan: What's your dream for the space gallery?

Dunbar: It is called the west-side development, with a space gallery, and a commercial aviation gallery, which would have our Concord and all the large aircraft in it. On the north side, would be Aviation High School. The space gallery would have the Space Shuttle in the front part of it. We currently have a space gallery which we are using as a template for our new building.

We have the Magic Planet in our exhibit. You can touch a keypad and change the planet in front of you from Earth to Mars to Neptune. You can watch the water recede and return on Earth. You can go through a full-size module of the International Space Station Destiny Lab. You can land the shuttle or a lunar launch.

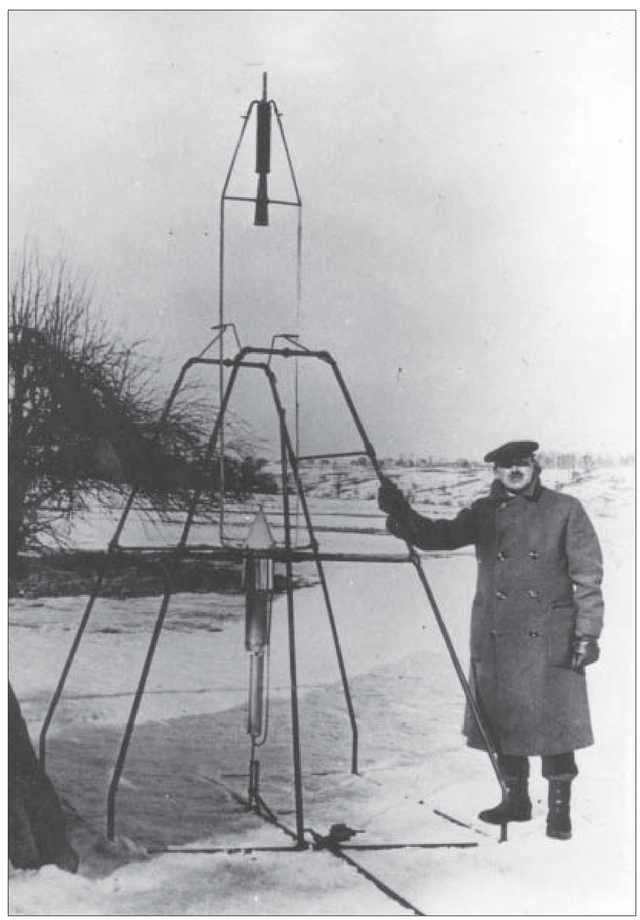
We'd take that kind of immersive environment over across the street. And hopefully, we'd not only educate—because that's our role as a museum—but we'd inspire the future.

So we'll apply for the shuttle and hopefully get it. *(Editor's Note: The Space Shuttle Fleet is slated for retirement in 2010.)* Not just for us, but for the *state*, for the Northwest. We will preserve our historical airplanes, symbols of everything we've talked about here in the Northwest, from a entrepreneur named Bill Boeing Sr., who transformed commercial air transportation in the world. We are inviting the Aviation High School (AHS) to build it's high school as part of our campus. We wish to serve more youth, and to help inspire the next generation. I call it building your SRU, your Self Replacement Unit, as we all should do. You do it through your children and you do it through other people around you.

Everything that we have learned in 8, 000 years of recorded civilization does not automatically transfer via brain transfusion, it is taught. How we would hate to start all over! So, how do we take everything we've learned, the rules of society, what's right, what's wrong, what works, the history, the science, engineering, how do we communicate that to the next generation?

Heffernan: How will you measure your own success?

Dunbar: If you have one person in an audience who seems to resonate, that's a reward because maybe that one person will make a difference. But you also have to accept the fact that maybe the difference doesn't come until your long gone. You know, some of my heroes didn't live during my lifetime. Robert Goddard became a hero once I realized how ostracized he was in the 1920s when he talked about designing rockets to escape Earth's gravity, but went on to success.



Dr. Robert H. Goddard, a hero of Dunbar's, and his liquid oxygen-gasoline rocket which launched on March 16, 1926 at Auburn, Massachusetts. According to NASA he is considered by many as one of the fathers of rocketry. *NASA photo.*

Heffernan: Is there anything else that you'd like to mention as part of your oral history?

Dunbar: I want to make sure due credit is given to the faculty I had at the University of Washington, particularly Dr. James I. Mueller, Chairman of the Department. He was *always* a great supporter of mine.

We talked about the introductions to NASA engineers. People like Bill Scott or O.J. Wittemore were just (part of a) tremendously great faculty. I had a first-class education at the University of Washington.

I had wonderful managers at Rockwell including President of the Space Division, George Jeffs and Vice President Joe Cuzopolli. At NASA, I worked with wonderful people: NASA Johnson Space Center Director Chris Craft allowed me to finish my PhD. My PhD thesis adviser was Dr. Bob Nearham, Chair of the Mechanical Engineering Department. Dr. Irene Peden, professor of electrical engineering here at the University of Washington and other women engineers like Shirley Holmgree and Elizabeth "Pete" Plunketts. Anita Gale, a college friend of mine, called me about opportunities at Rockwell when I interviewed there. I had great opportunities working at Edwards Air Force Base in Palmdale on the Space Shuttle *Columbia*. I worked as a flight controller at NASA with Gene Kranz.

Heffernan: Who were your greatest mentors at NASA?

Dunbar: Oh, many, many, *many*. Where do I start? I didn't have any single one. I worked for Mr. Abbey. Jim Shannon was one of my bosses. Part of my faculty, or my review committee at the University of Houston, but who was in charge of NASA biomedical labs was Dr. Carolyn Huntoon. Carolyn was probably the reason for most of the women being selected. She was the *only* woman on the astronaut selection panel for the shuttle. And so we all were very grateful to what Carolyn's role was in terms of selecting women into the astronaut program. She eventually became Center Director. All of them are tremendously important.

Heffernan: When you reflect on your career filled with these great people and your life, what do you see as your crowning achievement?

Dunbar: I hope I'm not at the point to look back and count amongst what I've already done. I'd like to think that it's still ahead of me.

Bonnie Dunbar on board *Columbia* in 1990. STS-32. *NASA photo.*

Heffernan: Do you have any regrets?

Dunbar: No. I had a wonderful career at NASA as a flight controller as a crew member on five flights. I still have friends there. Still stay connected and support…. NASA belongs to all of us. It's the only human space flight organization that we support as a nation.

Heffernan: Looking back, would you lead your life the exact same way?

Dunbar: I would take the same pathway. Every decision I've made I would make the same. But I would try to lead a better life. I mean we're never born perfect. You look back and there are some things that we would have done a little differently.

Heffernan: Do you have imperfections, Dr. Dunbar? (laughing) How could you possibly do more?

Dunbar: Well, I'm just talking about who you are as a human being too. For some reason, I always felt that I had to do things fast and early because I was compelled that way. I did all the fun things that you can do too. But I always thought that people were invincible. I never thought about death, until my brother was killed in Vietnam. Sometimes you forget to thank people or say something you'd like to say to them at the time. So, there are just things I wish I had said to people before suddenly they were gone.

It's advice that was given to me by one of my professors at Harvard when I went to the Managers in Government Program, and he was helping to teach it. And he had been very well known and influential at one time at the White House. So, he was spending his time reaching back and thanking all the people who helped him. And I think it's very important. So one of my goals has been to, when I take those opportunities, to go back and say thank you teachers, thank you parents, thank the people who helped you if you can find them, along the way. *(Editor's Note: Dunbar lost her brother, Robert Dunbar, in Vietnam. Tragically, in 1986 her brother Gary Dunbar died in a house fire caused by an* *electrical problem. She is private about the family loss and hardship.)*

Heffernan: Are you disappointed that you didn't get to go to the Moon?

Dunbar: You can waste a lot of energy being disappointed about things you didn't get to do. I think I'm a glass-half-full person. The fact that I even got to fly in an airplane is pretty remarkable to me.

Heffernan: When you envision the world 50 years from now, and if the budget were not an issue, how do you see the human spaceflight program?

Dunbar: Well, you used the operative word, "human." You didn't say U.S., you didn't say Chinese, Russia, European, or Japanese. You said human. I think humans will go a long way in this century; I just don't know if it will be the United States.

Heffernan: Any important lessons, any advice you would give to people a hundred years from now who are dealing with their own challenges and passions?

Dunbar: The advice I give is that everyone has their own path to lead. I don't take on the mantel of a moral leader.

Heffernan: Understood.

Dunbar: But what I care about, and what I think is so important, I think is so critical for civilization as we are and that is to continue exploring, continue learning, to keep an open mind. Civilizations will start to deteriorate when they cease to be excited about exploring and learning. Or they start drawing lines between groups of people, or start believing in non-scientifically supported hypothese, such as the Earth is flat. I think we've gone past that, but I know there is still the Earth is flat society out there. There are even people who still believe we haven't been to the Moon. It's wonderful that we have a lunar observer up there now taking pictures of our spacecraft which I *hope* will put some of that to bed. When we went to the moon 40 years ago, the *whole* world watched that, and we ought to be proud that we were leaders doing it because this has benefited our society in many ways. Not just the quality of life and the technology. The quality of life has freed us for other pursuits and learning. Philosophy, political leadership, democracy. So we should never underestimate the role that science and technology has had in every major civilization since the dawn of time. Do away with science and technology and you start to undermine the very form of government.

The Moon. NASA photo.

Heffernan: I know you have unfinished business. But what do you hope, at least up until this point, is the legacy of Bonnie Dunbar?

Dunbar: Legacy is a big word. I've always hoped, like I think any human being hopes, that I will leave some sort of mark on civilization, even if it's a small one just through deeds. My father was not in a history book, that I know of, but he was a remarkable person who made a mark. People remember him, and I think that's important.

Heffernan: Thank you very much, Dr. Dunbar what an extraordinary life and career. It's been a great pleasure.

Dunbar: You're welcome.

End of Interview

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