

PROJECT APOLLO

Reaching for the Moon

A series of articles from the *Astronomy* archives



Astronomy

Moonwalk

► In this iconic picture that includes Neil Armstrong's first steps on the Moon, Buzz Aldrin's helmet reflects Armstrong's shadow and image, as well as that of the lunar lander that they set on the surface. NASA

HOW ONE SMALL STEP BECAME A GIANT LEAP

A billion people watched Neil Armstrong step onto the lunar surface in 1969. But space reporter **JAY BARBREE** was there for all the steps before that.

Neil Armstrong stared out at the alien world beyond his lunar lander's window. He was surprised at how quickly the dust, hurled away by the final thrust of *Eagle's* descent rocket, had settled back on the surface. Within the single blink of an eye, the Moon had reclaimed itself as if it had never been disturbed, and Neil studied the desolation surrounding himself and Buzz Aldrin. No birds. No wind. No clouds — a black sky instead of blue.

It was obvious NASA had made the correct decision regarding who would be first to leave the lunar lander. Outfitted in his bulky spacesuit, boots, and backpack, there was no way Buzz could have maneuvered around Neil to the hatch. The commander simply had to be the first to leave and the last to return. Neil leaned forward, backing out, stopping on the porch with its large handrails leading to the ladder.

He moved slowly and steadily as if he had no place to go. The Moon had been waiting for 4.6 billion years, and Neil was in no hurry. Every move had to be precise, correct, no problems.

Soon, he was a step above lunar dirt, and he paused, staring at *Eagle's* landing footpads and legs. They had been designed to compress with the force of landing, making the

ship more stable, bringing its ladder closer to the surface. But Neil's piloting skills proved to be the problem. He sat *Eagle* on the Moon so gently that there was no collapsing of the pads and legs, and the bottom rung of the ladder was still 3.5 feet (1.1 meters) up.

Way to go, Armstrong, he scolded himself as he dangled a foot over the rung and fell slowly to the footpad beneath him. But before he would take another step, he wanted to be sure he could get back up to the ladder. In the low gravity, he sprang with such force that he almost missed the bottom rung. He steadied himself. Satisfied he could handle the extra-long step, he descended back onto the footpad.

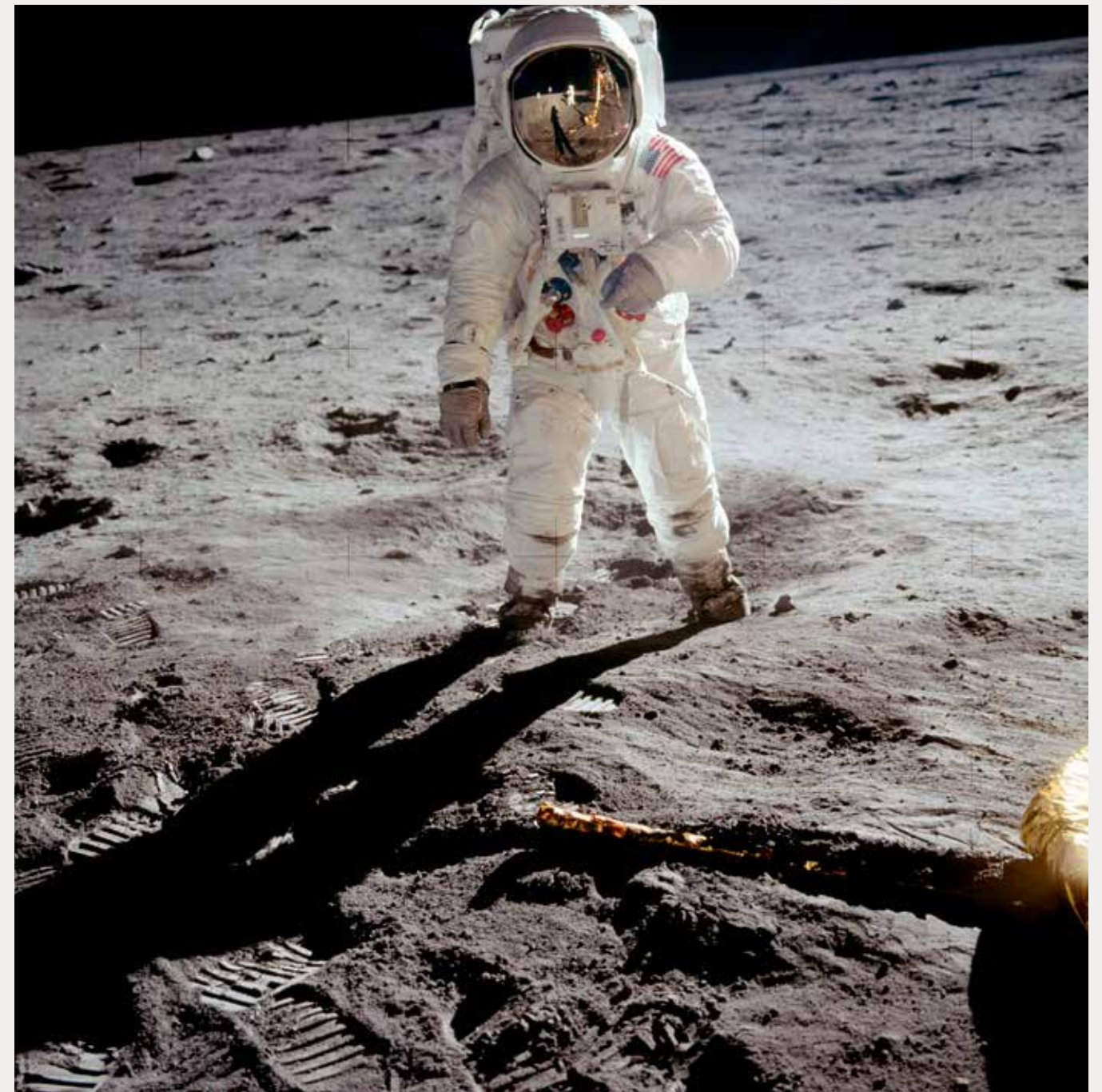
"OK, I just checked getting back up to that first step, Buzz. It's not collapsed too far, but it's adequate to get back up."

"Roger. We copy," acknowledged Cap-Com in Houston.

"It takes a pretty good little jump," Neil told them before turning his attention to his dilemma. For some time, he had been thinking about what he would say when he actually stepped on the Moon. He had thought about one statement he judged had meaning and fit the historic occasion, and he ran it by his brother, Dean, and others close. Neil had not made up his mind.



Neil Armstrong snaps a picture of the Apollo lunar module from afar. NASA



He told me he was undecided until he was faced with the moment.

He reached up with his gloved hand grasping the ladder and then turned left, leaning outward. "I'm going to step off the LM now," he said, lifting his left boot over the footpad and setting it down in Moon dust that shot up and outward in a fine spray — a spray that lasted only a quick instant in the absence of an atmosphere. "That's one small step for man," Neil said with a momentary pause, "one giant leap for mankind."

Most didn't know Neil had meant to say, "That's one small step for a man," and the loss of the *a* set off an argument for years to come. Had a beep in the transmission covered the *a* or some other

loss of transmission wiped it from our ears, or had Neil nervously skipped the word?

Knowing Neil's struggles with public speaking, I believe the latter, and with all the excitement and emotions of the moment, I've never been convinced Neil himself really knew for sure.

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HIS MOTHER HAD TOLD HIM her only real concern for his safety on the Moon was the lunar crust might not support him. Again, Neil tested his weight. Then he told Mission Control, "The surface is fine and powdery. I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and



With dinner cut short, author Jay Barbree returns to his microphone to report Neil Armstrong's first steps on the Moon. NBC/NASA

sides of my boots. I only go in a small fraction of an inch, maybe an eighth of an inch, but I can see the footprints of my boots and the treads in the fine sandy particles."

He stood there rock-solid, boots braced for balance, enclosed in the elaborate pressurized exoskeleton that sustained his life on this inhospitable place. It was filled with energy, with supplies of heat and cooling, water, oxygen pressure — a capsule of life created by his Apollo colleagues, and Neil Armstrong stood looking long and hard at this small, untouched world.

He was overwhelmed. His sense and his thoughts set afire with the miracle of being on the lunar surface. He believed that he and Buzz and those who would follow were there for far more than walking through lunar dust and measuring solar winds, magnetic fields, radiation levels — all that was window dressing for their real purpose for coming.

It all condensed into every view they had of their fragile, beautiful Earth.

It was suddenly clear to this son of the land once walked by Orville and Wilbur Wright that he was on the Moon to look back — to give every single human a clear look at spaceship Earth carrying the miracle. In this neighborhood of the universe, it was life's only world. It was encased in diamond-hard blackness, and Neil recognized it mattered little if we were Republican, Democrat, Independent, apolitical, Christian, Jew, Muslim, Hindu, or Buddhist, or who the hell we liked or disliked. We live on a vulnerable world where we must take care of its very finite resources — on a world where we all would suffer terrifying consequences if we drained it of its ability to sustain us — its ability to foster and nurture the very life we now threaten to contaminate. Neil knew no matter how diligent, how great

Jay Barbree is the author of Neil Armstrong: A Life of Flight (Thomas Dunne Books, 2014), from which this article is an excerpt.

our effort to protect Earth, it was finite, and one day if humans were to survive, they would have to move on to new worlds. In the greatest of reasons, that was what he and Buzz and all those who would follow were here doing walking on the Moon.

Neil stopped his thoughts, forced himself out of his introspection. He and Buzz had much to do before they could catch a few hours' rest, and he turned and began walking farther away from the security of *Eagle*.

In one sense, it was like learning to walk again — shuffling, stiff-legged, yet buoyant — something like wading through chin-deep water with his feet striking bottom — floating in low gravity within his spacesuit.

On Earth, his exoskeleton weighed 348 pounds (158 kilograms). Now, on the Moon, it only weighed 58 pounds (26kg), and he told Mission Control, "There seems to be no difficulty in moving around as we suspected. It's even perhaps easier than the simulations at 1/6-g that we performed. It's actually no trouble to walk."

Neil's first task was to collect a contingency sample. If they had to abort the moonwalk early, a small bag of lunar soil would make scientists happy. But he told himself he should do that in sunlight, and for now he needed the camera. He needed to take pictures while his eyes were still adapted to the shadows.

"OK, Buzz," he asked his partner, "we ready to bring down the camera?"

"I'm all ready," Buzz told him. "I think it's been all squared away and in good shape, but you'll have to play out all the LEC [Lunar Equipment Conveyor]. It looks like it's coming out nice and evenly."

Neil mounted the camera on a bracket on his chest and stepped forward to take the number one photograph. It was to have been his first footprint on the Moon, but no sooner than he looked for it by the footpad, he was ready to kick himself. In his movements to check out *Eagle's* stance and operate the conveyor line to bring the camera down, he had walked over it. It was obvious his later steps had blotted out his first.

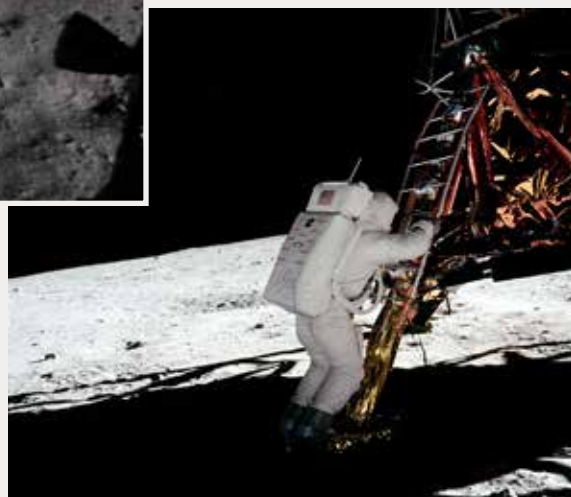
Then Bruce McCandless called, "We see you getting some pictures and the contingency sample, Neil."

Neil didn't move. He stood there disappointed with the loss of the first footprint, and McCandless asked again, "Neil, this is Houston. Did you copy about the contingency sample, over?"



Neil Armstrong gets the contingency sample and makes sure all is well for Buzz Aldrin to join him on the lunar surface. NASA

After Neil Armstrong stepped from the Apollo 11 lunar module onto the Moon's surface, he watched Buzz Aldrin descend *Eagle's* ladder and land for the first time on nonterrestrial territory. NASA



No one was more aware than Neil how important the contingency sample was, and he told Bruce, "Roger, I'm going to get to that just as soon as I finish these picture series."

Buzz watched as Neil completed the photographs and walked away to a sunlit area. He asked, "Going to get the contingency sample there, Neil?"

"Right," Neil answered.

"OK. That's good," Buzz agreed.

Neil quickly reached into a thigh pocket and withdrew a collapsible handle with a bag on its end. He was in sunlight for the first time, and he turned his back on the penetrating glare. He began digging into the surface. What he found surprised him. There was the same soft powder, but then there wasn't. He met resistance. "This is very interesting," he told Mission Control. "It's a very soft surface, but here and there where I plug with the contingency sample collector, I run into a very hard surface. It appears to be very cohesive material of the same sort." He scooped up enough lunar soil to fill the bag and told them, "I'll try to get a rock in here, just a couple."

"That looks beautiful from here, Neil," Buzz told him, talking about the sample, but Neil took Buzz's comment to mean the Moon. "It has a beauty of its own. It's like much of the high desert of the United States. It's different, but it's very pretty out here."

Pointing down from *Eagle* was a 16mm movie camera loaded with color film. It was there to film the actions of the two astronauts on the Moon, and Buzz told Neil, "OK. I have got the camera on at one frame a second."

"OK."

"Are you ready for me to come out?" asked Buzz.

"Yes," Neil said, and Buzz followed his instructions, asking, "How far are my feet from the edge?"

"You're right at the edge of the porch."

"OK. Now I want to back up and partially close the hatch," Buzz reported, quickly adding, "making sure not to lock it on my way out."

"A very good thought," Neil agreed, as a wave of laughter rolled through Mission Control.

★★★★★

BUZZ MOVED SLOWLY DOWN and then said, "OK, I'm on the top step, and I can look down over the landing gear pads. It's a very simple matter to hop down from one step to the next."

"Yes, I found I could be very comfortable, and walking is also very comfortable," Neil agreed, pausing long enough to recheck Buzz's progress. "You've got three more steps and then a long one."

"OK. I'm going to leave that one foot up there and both hands down to about the fourth rung up."

"There you go."

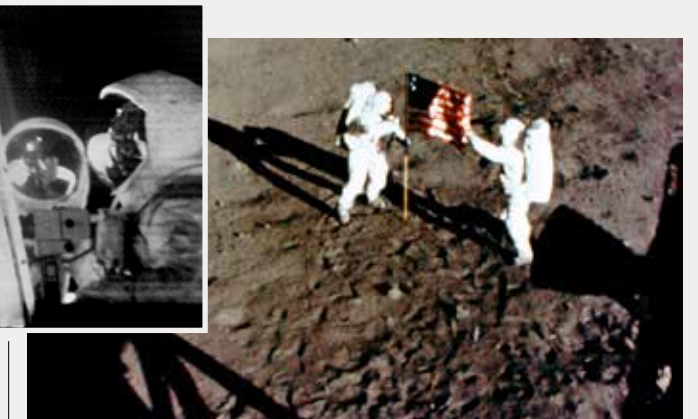
"OK. Now I think I'll do the same."

"A little more," Neil suggested, "about another inch." There was a pause, and then Neil shouted, "There, you got it!"

A second human was on the Moon, and Neil greeted Buzz at the bottom of the stairs as they again heard cheering in Mission Control.



The Apollo 11 astronauts set up a television camera on the Moon's surface, beaming back a feed of their activities. Here, Neil Armstrong (left) and Buzz Aldrin stand near the ladder that led them to the lunar surface. NASA



The flag that the Apollo 11 astronauts planted in the lunar soil was stiffened with wire so it would not lie limply against its pole on Earth's airless satellite. NASA



Left on the *Eagle* lander on the Moon's surface, this plaque reads, "Here men from the planet Earth first set foot upon the Moon July 1969, A.D. We came in peace for all mankind." NASA

"Beautiful view," Buzz grinned.

"Isn't that something?" Neil agreed.

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"MAGNIFICENT DESOLATION," Buzz spoke with feeling as he stared at a sky that was the darkest of black. No blue. No birds. No green below. There were many shades of gray on the surface and areas of utter black where rocks cast their shadows from an unfiltered Sun, but no real color. Possibly tan under certain lighting.

The land curved gently but noticeably away — all the way out to the horizon that was only half the distance Buzz and Neil were used to seeing on Earth. But there on the Moon, they could actually see they were standing on a sphere, and when they walked and looked down, their motion fascinated them. Each time they took one of their half-walking and half-floating steps, their boots set in motion a spray of lunar soil sailing outward and upward sharply and quickly without the hindrance of an atmosphere, and they even tried running and leaping strides that were impossible to do on Earth. But when they tried to sustain a jog, the mass and velocity created kinetic energy, and stopping quickly was impossible.

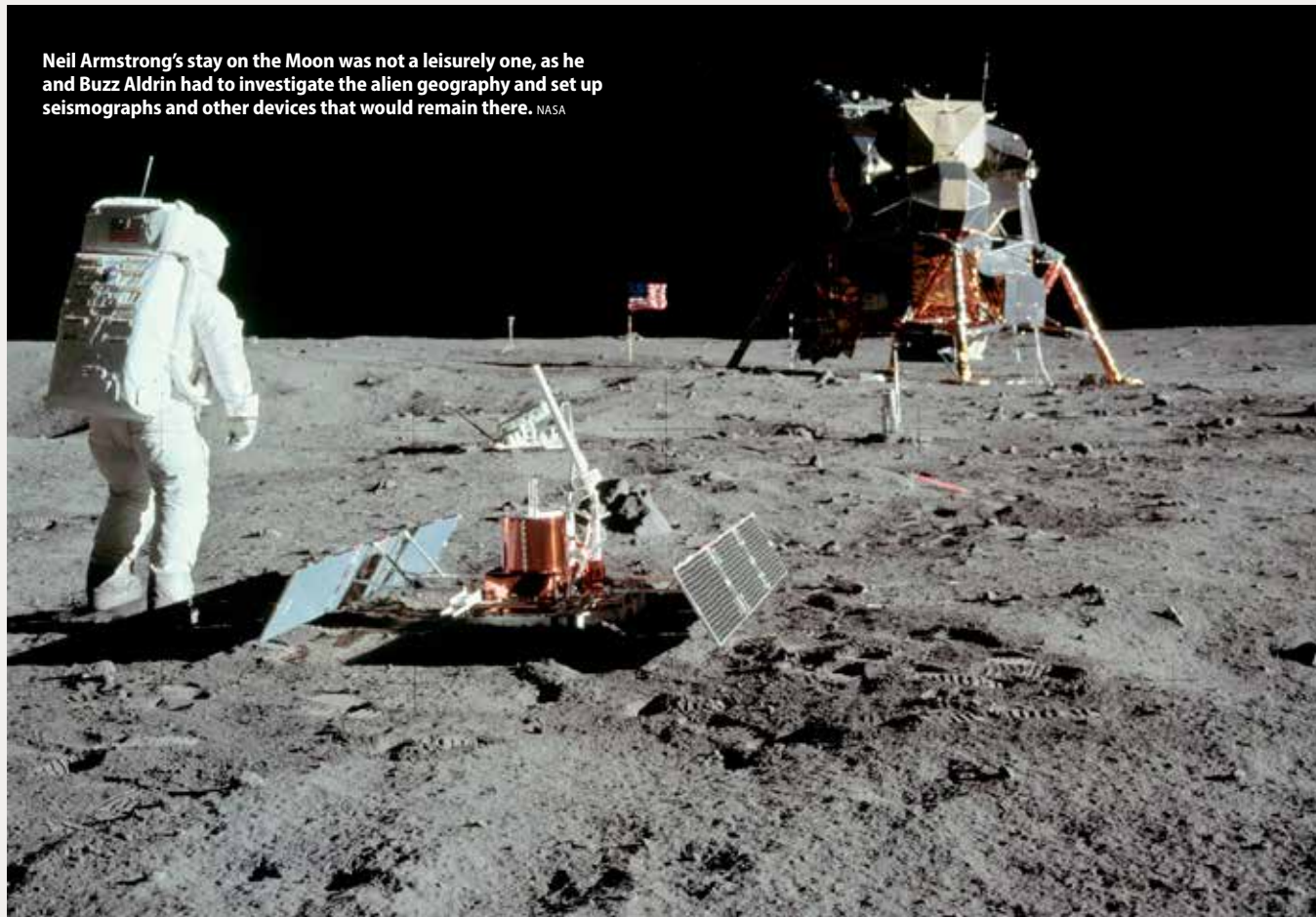
It was as if they had found a new playground after school, and they even tried bunny hopping, an assortment of moves, and they wished they could stay on their new playground until they had explored every nook, every cranny, so much to see and do and so little time.

But despite their wish to drink in this new and strange and beautiful and wonderful place, Neil and Buzz had to move on to their chores.

First, they reset their television camera's location 60 feet (18m) from *Eagle*. This would help earthlings see some of the things they were seeing.

Next on their list of duties was to plant the American flag. By international agreement, no country could claim the Moon, even

Neil Armstrong's stay on the Moon was not a leisurely one, as he and Buzz Aldrin had to investigate the alien geography and set up seismographs and other devices that would remain there. NASA



the first to get there. That was stated firmly in a plaque on *Eagle's* front leg.

"For those who haven't read the plaque," Neil told the television viewers, "it says, 'Here men from the planet Earth first set foot upon the Moon July 1969 A.D. We came in peace for all mankind.' It has the crew members' signatures and the signature of the president of the United States."

Neil and Buzz then unfurled an American flag stiffened with wire so that it would appear to fly on the airless Moon. But the Moon's subsurface was so hard, they could barely get its pole to stand. Once they did, they moved back to clear the view of the 16mm color movie camera looking down from *Eagle's* window.

Then there were other protocols to meet.

In the lunar dust, Neil and Buzz placed mementos for the five deceased American and Russian space flyers, and one small cargo — private and honorable — carried by Neil. It was not to be divulged. It was a diamond-studded astronaut pin made especially for Deke Slayton by the three Apollo 1 astronauts who planned to fly it on their mission before that dreadful fire.

And yet there was one other remembrance. Very special and dear to Neil, a part of an unfinished life he so wanted to leave on the Moon, and he did.

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SO THE ESTIMATED BILLION PEOPLE on Earth watching could keep track, Neil relocated their television camera to its cable's

limits. Those viewing could now see even more, and CapCom told him, "We've got a beautiful picture, Neil," adding, "Could we get both of you on the camera for a minute, please?"

"Say again, Houston," Neil asked.

"We'd like to get both of you in the field of view of the camera for a minute."

Buzz was in the middle of setting up experiments, and while he found the request puzzling, he moved in front of the camera.

"Neil and Buzz," CapCom Bruce McCandless told them, "the president of the United States is in his office now and would like to say a few words to you, over."

"That would be an honor," Neil responded.

"Go ahead, Mr. President. This is Houston out."

"Hello, Neil and Buzz," President Richard Nixon began, "I'm talking to you by telephone from the Oval Room at the White House, and this certainly has to be the most historic telephone call ever made. I just can't tell you how proud we all are of what you are doing for every American. This has to be the proudest day of our lives. And for people all over the world, I am sure they, too, join with Americans in recognizing what an immense feat this is. Because of what you have done, the heavens have become a part of man's world. And as you talk to us from the Sea of Tranquillity, it inspires us to redouble our efforts to bring peace and tranquility to Earth. For one priceless moment in the whole history of man, all the people on this Earth are truly one; one in their pride in what you have done, and one in our prayers that you will return safely to Earth."

There was a long silence, a grateful silence by a listening world, and Neil responded: "Thank you, Mr. President. It's a great honor and privilege for us to be here representing not only the United States but also men of peace of all nations, and with interest and a curiosity and a vision for the future. It's an honor for us to be able to participate here today."

"And thank you very much, and I look forward," President Nixon told Neil, "all of us look forward to seeing you on the *Hornet* on Thursday."

"I look forward to that very much, sir," Buzz joined in.

Neil and Buzz would find in the future when they were making their world tour that they would be greeted by people everywhere saying "we," not just the United States, "We did it — we went to the Moon!"

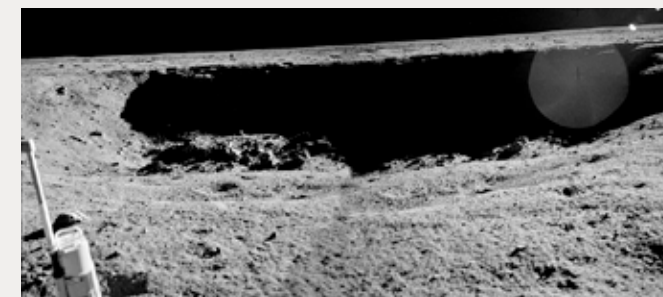
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THERE WAS SO MUCH MORE THEY WANTED TO DO, but Buzz found the Sea of Tranquillity more rugged than he'd expected. There were high and low areas — not the best place to set up the experiments — but he managed to deploy a solar-powered seismometer to detect moonquakes and a laser reflector to help scientists measure the distance at any given time between Earth and the Moon. Buzz and Neil were most pleased when Mission Control told them they were giving them an extra 15 minutes.

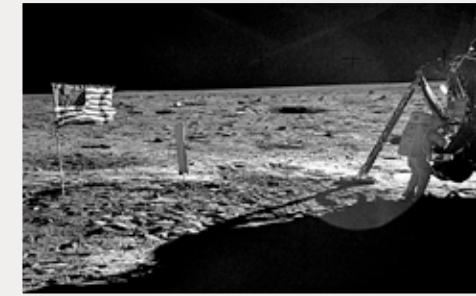
When they had the solar-powered seismometer running, Tranquillity Base appeared to be a fully operating scientific outpost. Neil left the experiments to Buzz and began moving about their landing site, exploring on his own.

He quickly abandoned any thoughts of trying to reach and inspect the football-field-sized crater he had to avoid during landing. But there was a smaller crater he'd flown over only about 200 feet (60m) away.

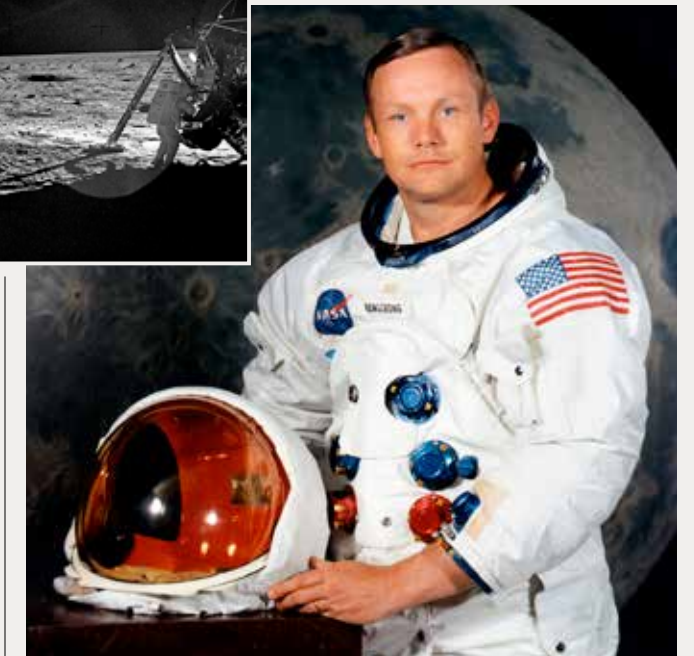
A baby crater, Neil thought, Muffie's Crater. He smiled, quietly remembering the 2-year-old he and Janet had lost to a brain tumor, and he permitted himself a moment. He stood there, remembering how Muffie would have loved sliding down into the pit. He had an overwhelming urge to do it for her. He'd love to have a sample of lunar bedrock anyway for the geologists. But



Neil Armstrong lost his 2-year-old daughter, Muffie, to a brain tumor. Imagining how she would have liked to slide down this crater, he named it after her. NASA



The flag Neil Armstrong and Buzz Aldrin planted on the Moon gives the same frozen wave today as it did the day they left. NASA



Astronaut Neil Armstrong's official NASA photo shows him in an Apollo mission suit, which he later wore as the first person to walk on the Moon. NASA

then better judgment grabbed him. What if he couldn't get back up without the help of Buzz?

He settled for taking pictures and describing what he saw before heading back where Mission Control had put Buzz to work hammering a metal core tube sample into the hard subsurface. They then told Neil to gather rocks that would best represent the Sea of Tranquillity.

With time running out, they moved back to *Eagle's* ladder, and Buzz was told to head back in. But before he did, he took the camera from Neil and photographed the Apollo 11 commander loading lunar material boxes on *Eagle*.

Neil sensed that if he came back to this same location on the Moon a million years from now, he would find the scene as he had left it. In his visit, he had little time to get to know this small corner of the solar system. Yet the knowledge and the samples from the Moon he and Buzz were bringing back were priceless.

He joined his moonwalking partner inside *Eagle* to welcome the loud noise of oxygen filling their lander's cabin — the livable atmosphere they would need to take their helmets off. When they did, they were met with a pungent odor — wet ashes and gunpowder. They were bringing the smell of the Moon with them.

Neil Armstrong and Buzz Aldrin had landed on the Moon on Sunday, July 20, 1969, at 4:17:42 P.M. EDT.

Six hours and 38 minutes later, Armstrong became the first human to set foot on the lunar surface. Aldrin followed him 18 minutes later to become the second. Apollo's lunar landings would end after 12 Americans walked and rode in lunar cars across the Moon's landscape. The last Apollo returned from the lunar surface December 17, 1972.

No human has visited the Moon since. ☞



TO SEE MORE APOLLO 11 PHOTOS, VISIT www.Astronomy.com

Jim Lovell

IN HIS OWN WORDS

The only person to fly to the Moon twice but never trod its surface has some amazing stories to tell. **by Richard Talcott**

In today's celebrity-obsessed culture, the word *hero* gets bandied about far too often. But what other term would you use to describe astronaut James Lovell? A veteran of four spaceflights, his accomplishments paved the way for the first Moon landing and helped define NASA's can-do attitude.

In December 1965, he and Frank Borman flew on Gemini 7, where they performed the first rendezvous with another manned spacecraft (Gemini 6A). In November 1966, he teamed with Buzz Aldrin on Gemini 12, the final mission of the Gemini program. But Lovell's main claim to fame came during the subsequent Apollo program. He served as the command module pilot on Apollo 8 — the first manned spacecraft to leave Earth's gravity and orbit the Moon. And he was commander on Apollo 13, which suffered a crippling explosion on its way to the Moon and barely made it safely back to Earth.

Recently, *Astronomy* Editor David J. Eicher and I interviewed Captain Lovell about his Apollo missions at Lovell's of Lake Forest, his restaurant in suburban Chicago. At 86, he remains every bit as sharp and entertaining as he was during his NASA days, when astronauts were this country's true heroes.



ASTRONOMY: DAVID J. EICHER

ASTRONOMY: Thanks, Captain Lovell, we certainly appreciate your being here today and having this interview with us. Apollo 8 was the first of many missions that went to the Moon, and you did a lot of things for the first time. Did it help with your comfort level to have Frank Borman with you, since you had flown with him earlier?

LOVELL: Yes, Frank and I flew for two weeks on Gemini 7, in a small little container called the Gemini. Some people call it two weeks in the men's room. I was particularly happy to be on [Apollo 8] because it was the first time that we'd navigated the entire 240,000 miles [385,000 kilometers] to the Moon. When I was with Charles Lindbergh on the beach watching

Senior Editor **Richard Talcott** watched with rapt attention as Jim Lovell twice journeyed to the Moon and back during the Apollo program.

Apollo 11 lift off, he said, "You know, Apollo 8 was almost like my flight across the Atlantic [because of] the long distance — all Apollo 11 had to do was land."

ASTRONOMY: Your Apollo mission originally was planned to test the lunar module in Earth orbit, but delays in the lunar module program changed those plans. How lucky did you feel that the mission order changed so that you were able to be on the first flight to the Moon?

LOVELL: Well, I was pretty happy. I had already been up twice, and this would have been three times to go around again doing about the same thing. I was the command module pilot, so I would have been in the command module, not in the lunar module. As a matter of fact, I started out being on the Apollo 11 flight and Mike Collins was on Apollo 8. He had a neck injury that

had to be repaired before he could fly, so I replaced Mike on Apollo 8, and he took my spot on Apollo 11.

ASTRONOMY: I take it you weren't necessarily disappointed with that?

LOVELL: No, that's exactly right. Because on Apollo 11, I would have been the command module pilot, orbiting again. Being the first to go to the Moon on Apollo 8, that was something I really enjoyed.

ASTRONOMY: What were your thoughts when you became the first people to leave Earth's gravity behind?

LOVELL: It was a unique feeling in many respects. First of all, we were like three school kids looking down on the farside of the Moon when we first went around there. The ground was tracking us at this time, and they said that at such and such



The crew of Apollo 8 — (left to right) Jim Lovell, Bill Anders, and Frank Borman — pose on a simulator at Kennedy Space Center just a month before they took off for the Moon. NASA

“Boy, how fortunate we all are to have a spot like that to go back to, and hopefully, we can make it back home.”



Earth rises over the Moon's limb as Apollo 8 comes out from behind the Moon on its fourth orbit. The lunar horizon lay approximately 485 miles (780 kilometers) from the spacecraft when Bill Anders captured this iconic scene. NASA

a time, down to the second, you'll lose communication with us. By gosh, right on the second, we whipped around the far-side and lost communication. You know the Moon has three different shades. In sunlight, it's quite bright; in earthshine, it looks like snow outside at nighttime here on Earth; and then there's the part that has no earthshine, no sunshine — you don't see a thing. And that's the only time when all the stars came out.

ASTRONOMY: How were your preparations for Apollo 8? Did they prepare you for what you actually saw at the Moon, or was it totally different from what you were expecting?

LOVELL: Well, when we got word that we weren't going to do Earth orbit on Apollo 8 but go to the Moon, we had to change a lot of things — navigation was the big thing. The training was very good; there was nothing, I would say, that was a complete surprise to us.

The big surprise is the Earth — it's not a surprise that we thought we're going to see something else — but just suddenly looking at it and seeing it as a small body that

you can completely hide behind your thumb. You're only 240,000 miles away, but everything that you have ever known is behind your thumb — all the history of the Earth and all the people you knew and all the problems. It is merely a small body that's orbiting a rather normal star, and it just happens to be at the proper distance with proper mass to support life.

And then I thought how insignificant we really all are. The Sun itself is tucked away in the outer edge of a galaxy called the Milky Way, and that's only one of millions of galaxies in the universe. And here's this little body sitting out there 240,000 miles away, and I thought, “Boy, how fortunate we all are to have a spot like that to go back to, and hopefully, we can make it back home.”

ASTRONOMY: When you read from the book of Genesis on Christmas Eve, was that a joint decision among all three of you, or did one of you come up with that idea?

LOVELL: That's kind of interesting. When we were planning our trajectory, all of a sudden it dawned on us that the day we were shooting to take off, on the 21st

of December, we would be orbiting the Moon on Christmas Eve. We decided, gee, it's going to be Christmas, what can we say? We've got to think about something to say. So we thought, well how about changing the words to “The Night Before Christmas”? That didn't sound too good. Or how about “Jingle Bells”? No, that was even worse. So we were at an impasse.

We knew a friend who said, “I know a newspaper reporter, and they usually have a gift of gab about writing things like this. I'll ask him.” The story I got was that he spent one night trying to figure out what these three people should say. Around midnight, his wife came down the stairs and said, “What are you doing?” And he told her the story that he was writing this thing for the Apollo 8 crew, but he hadn't really come up with anything yet. And she said, “That's simple — why don't they read from the Old Testament, the first 10 verses of Genesis? I mean, it's an emotional time, sort of a holy time, but the first 10 verses of Genesis is the structure of most of the world's religions.” So that's what we did. Wrote it down and put it on fireproof paper, and it was put in the back of the flight manual. That original flight manual and those words are now down at the Adler Planetarium [in Chicago].

ASTRONOMY: When you were on the farside of the Moon and getting ready to come back, did you have any concerns about the rocket firing?

LOVELL: I don't think anyone who makes these Apollo flights thinks about that rocket not firing. Of course, we were the first ones there. On the ninth orbit, we did Genesis and things like that and talked about the Moon. But on the 10th one, we wanted to make sure everything was ready. We called back [to Houston and asked for] some good words about what they thought we should put in the computer, exactly when we should fire the rocket, and the whole thing. And when we were on the farside, Mission Control never knew if it fired or didn't fire until we got around to the nearside. Of course, if it didn't fire, we'd still be in lunar orbit. It fired absolutely perfectly, right where it should. And I said to Mission Control: “Houston, please be informed — there is a Santa Claus.”

ASTRONOMY: You mentioned a little bit earlier about seeing Earth rise as you were going around the Moon. Did you have any idea after you got back how iconic that image would become and that it's been called one of the great images in the history of mankind?



Jim Lovell poses for his formal Apollo 13 portrait four months before the April 1970 mission. The mission's destination target — the lunar crater Fra Mauro — sits near the center of the Moon globe. NASA

LOVELL: When the Earth drifted over to my window and I looked at it — Bill [Anders] was the photographer — and saw the composition of the Earth with respect to the lunar horizon, I said, “Bill, this is it. This is the picture.” He had a telephoto lens on the camera, so that brought the Earth closer, where it was more pronounced and made it actually a much better composition, I think. We took lots of pictures, and we didn't know what picture NASA would actually release — whether the pictures of the Moon on the farside or the Earth in various places. It turns out that [“Earthrise”] was a great picture.

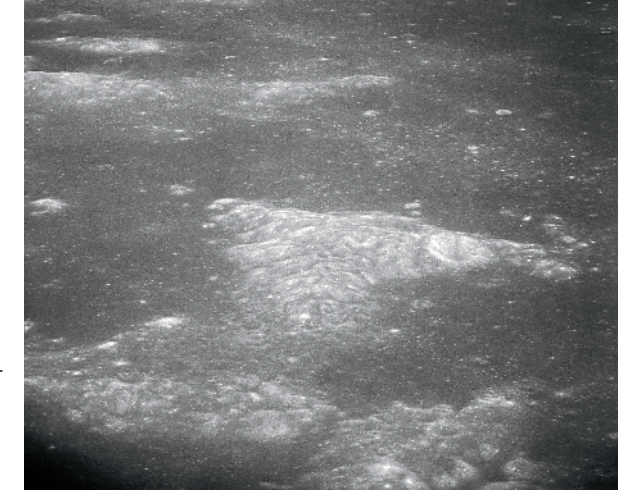
ASTRONOMY: Now we'll switch gears and discuss your next mission. Could you talk about how the objectives of Apollo 13 differed from those of Apollo 11?

LOVELL: Apollo 13 was actually going to be the first scientific Apollo flight. If you remember, there was a great space race between the Russians and ourselves. It started out in 1961 when Kennedy said we'd put a man on the Moon. This was a technical challenge, not so much of a scientific expedition. So 11 was successful. And just to prove that we could do it, because there were a lot of people in this country after Apollo 11 landed that said we faked it in West Texas someplace, we did Apollo 12. And it was successful — they landed within walking distance of the Surveyor [3] spacecraft. So these were

THE CASE FOR MOUNT MARILYN

ASTRONOMY: Jim, if you would, tell us a little bit about the intriguing story of Mount Marilyn.

LOVELL: When we were planning to go to the Moon on Apollo 8, we were looking at lunar charts. And we saw some of the nearside features — the area that we were going to fly over. And there was a little triangular mountain down there just on the shore of the Sea of Tranquility, and I looked at it and I looked it up to see if it had a name to it. It had no name to it. The crater [abutting it] had a name; it was called Secchi Theta. But the mountain itself had no name. And so I said to Bill and to Frank: “I think I'm going to name this Mount Marilyn, [after my wife].” And we can use it as sort of an initial point [a landmark that future crews could use as they began their final approaches] for our flight to see if it would be good for Apollo 10 and Apollo 11. And on the flight, we found out that it was very good. We saw it down there and mentioned it on Apollo 8. When we got back, we talked to the crews that were going to be on Apollo 10 and 11, [which



The triangular-shaped “Mount Marilyn” served as a point of reference for astronauts on both Apollo 10 and 11. The Apollo 10 crew snapped this oblique view during its May 1969 mission. NASA

would be following] the same trajectory, and they said “Yes, that's a good spot. We'll use that as an initial point.”

So it's in the [communications on] both of their flights, and then we sort of forgot about it for a long time. I kept referencing it sometimes, and Mount Marilyn got into the literature a little bit. It was in the movie *Apollo 13*. And finally, I thought to myself, we've made six landings on the nearside of the Moon, but there's nothing there to look at to represent those landings. Now [more recently], we have good photography on the farside, so the IAU [the International Astronomical Union — the official arbiter in naming solar system features] made a lot of new crater names of the

people who were in the program. But on the nearside, after six landings, there's nothing. So why don't we officially look at Mount Marilyn as the one thing that we can see from the Earth with a regular old telescope as the initial point for the first landing? I tried to get a little program going, and there were lots of people that were very interested. But the IAU, of course, says “No.”

ASTRONOMY: This name has been used systematically for decades now. It's high time to make it official.

LOVELL: I hope so, and I hope the IAU reconsiders our request to do something for this thing that represents all the people and our efforts to land on the Moon.

all really to prove the technology of going to the Moon and coming back.

By the time Apollo 13 came around, we realized that we better start looking at getting the science in the Apollo program. We were designated to land around a crater called Fra Mauro because [lunar scientists] thought that maybe there's ejecta [there that was dug out by big meteorite impacts]. We did a lot of geology fieldwork, and, if you look at the insignia of Apollo 13, it says “Ex Luna, Scientia” [From the Moon, knowledge] — that was the whole point of that mission.

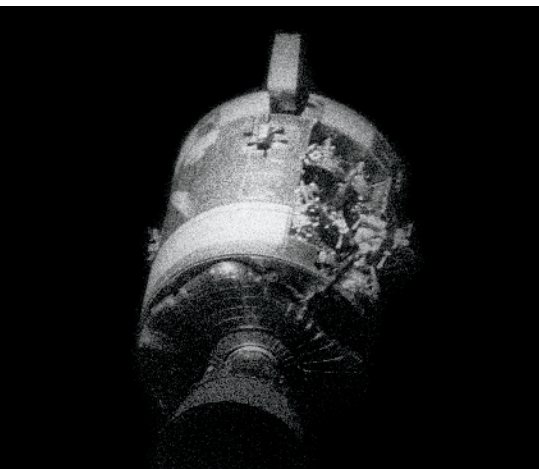
ASTRONOMY: Can you describe the liftoff of Apollo 13, and how did you feel heading to the Moon for a second time?

LOVELL: I was a lot more comfortable for the liftoff on 13. I had two rookies with me; this was their first time. Occasionally, they would look at me, and I would tell them what that noise was — when the

valves opened up and the fuel started running down toward the main engine, you could hear that rumble. I was very comfortable on 13 because I knew what to expect, up until the second stage engine shut down [about two minutes early]. We wondered whether we had enough fuel to go all the way to the Moon, but we did.

ASTRONOMY: This was your second trip to the Moon, your fourth flight into space overall. Were you used to the sights, the sounds, the smells, and how the stars appeared? Was it a familiar experience for you?

LOVELL: Yeah, to me, it was very familiar. They all came back, even the smells. There was no problem. Of course, when we got off the free-return course [a mid-course correction required to change the trajectory for the upcoming lunar landing], that kind of worried us a little bit because that put us in a position whereby



An oxygen tank exploded during Apollo 13's flight to the Moon and left the craft crippled. The blast blew away an entire panel on the service module, seen here after the astronauts jettisoned the module just before reentry. NASA

we wouldn't be able to get back to a safe landing on the Earth. But we had to do that to get the Sun in the proper position [for lunar orbit] so we could see the shadows of the rocks and boulders on the lunar surface. Because there is no atmosphere on the Moon, if you look straight down at noontime, it all washes out. You don't see anything. You had to have shadows to get a good perspective — a 3-D picture of where you're going.

ASTRONOMY: Can you describe the moment that you heard, in your words, a hiss-bang explosion?

LOVELL: Well, I was wondering what it was. There was an occasion beforehand where Fred [Haise] would turn the "repress valve" all the time, and it had a bang to it. I thought he was just trying to scare us, but he didn't do that. I wasn't too concerned at that time. I saw that we had an electrical problem at first, and I thought it might have been one of the batteries that we heard through the lunar module. But it turned out when we saw the oxygen escaping, that told us we were in serious trouble.

ASTRONOMY: How did you hold your composure in such an extraordinary and unprecedented moment of crisis?

LOVELL: Well, if you want to get in this business, you better be optimistic. I was a test pilot, and I had problems with airplanes before where I had to suddenly figure out what to do. I wasn't too sure at the time of the explosion that we were in danger until we saw the oxygen leaking. Then, we just had to figure out what to do. I thought our chances were probably pretty low at that time of getting back because

we didn't know exactly what the problem was back there — did we lose two oxygen tanks or did we just lose one? When we saw that two fuel cells had died and, of course, when we lost the oxygen, we then knew the other fuel cell was going to die because it uses oxygen and hydrogen to produce electricity and water.

That put us in a very tight spot. We were 90 hours and about 200,000 miles from home. And our lunar module, which was eventually used as a lifeboat to get home, was designed to only last 45 hours and support two people. Counting the crew — there were three people there.

ASTRONOMY: What was it like using the lunar module for propulsion and maneuvering? The craft was in an unprecedentedly tricky operation, was it not?

LOVELL: The lunar module had never been used [for this purpose]. It had been studied to use this technique but never had really been simulated. Of course, we're happy we had it. It had the landing engine on it, had its own fuel, its own oxygen — to last 45 hours and to support two people. The one thing we ran into was the fact that it was attached to the command/service module. The command module had the only heat shield that would get us through the atmosphere of the Earth after we would jettison everything else.

We found out when we tried to maneuver using the lunar module's control systems that we had not figured nor had the

lunar module been designed to be maneuvered with this mass attached to it. It's about a 60,000-pound [27,000 kilograms] dead mass that put the center of gravity way out in left field someplace. With the way the attitude jets were on the lunar module, [firing them] gave us a false movement. Put us someplace else. So, I had to learn to maneuver all over again. I had to know that when I maneuvered the handle somehow, what would happen to get me back into proper position.

ASTRONOMY: It was really an experimental process.

LOVELL: Quick learning.

ASTRONOMY: Mission Control frantically worked on plans and communicated with you to test plans for a return. You were working on the immediate crisis, and they were contemplating and communicating with you. What was the dynamic talking to them and working through it in that first period?

LOVELL: Well, at the beginning, it was very close. The one thing that we always had was the radio. And [Mission Control] were the ones that got us back on the free-return course while we were still married together with the two spacecraft. They were also involved with the speed-up. When we found out where we were, how much time we had to get home, we realized that we would not have enough electrical power to go around the Moon



Apollo 13 astronaut Jack Swigert sits in a rescue net as Navy personnel hoist him to a hovering helicopter. Commander Jim Lovell remains by the command module awaiting his turn. NASA

"I was incredibly relieved to think that we got back."

and get home safely before the power died. So they figured out how to speed up the spacecraft, first of all as we approached the Moon so that when we went around it we could light the lunar module engine and speed up to go back home again.

The one thing that I sort of complained about [was that] they had a hard time trying to figure out the final power-up of the command module — because it was dead. The guidance system had never been intended to be shut off for the entire flight. But we didn't have the [power to keep it warm]. And so they were trying to figure out the best way of powering up the command module to do the job.

They did a very good job, though, because we were being poisoned by our own exhalation. The lithium hydroxide canisters [on the lunar module] were designed to remove only carbon-dioxide exhalation from two people for two days, and we were three people for four days. It meant that we had to take a square canister, which had plenty of room in the command module, and sort of rig it into the environmental system of the lunar module that used round canisters that went into round holes. And you can't put a square canister into a round hole, obviously. So we ended up using duct tape, plastic, a piece of cardboard, and an old sock to sort of jury-rig this square canister on the outside of the lunar module system to remove the carbon dioxide. They did a very excellent job, and it kept us from being poisoned.

ASTRONOMY: Is it true that Jack Swigert and Fred were enamored with taking photos of the lunar farside?

LOVELL: About the time we were approaching the Moon, they wanted to take a picture of the farside. And, of course, I was waiting to get the instructions on how to start the engine and all that. In case I missed something, I was hoping that they would pick it up. And I said, essentially, "If we don't get home, you won't get those pictures developed." And they said, "Well, you've been here before, and we haven't." So they wanted to get pictures.

ASTRONOMY: What was the feeling of reentry through Earth's atmosphere like?

LOVELL: Well, as far as the spacecraft performing, it appeared just like it should because we managed to get all the power up on the command module again and with that we got the guidance system back up again. We realigned the guidance system — something which we learned



The Apollo 13 crew members — (left to right) Fred Haise, Jim Lovell, and Jack Swigert — can finally breathe a sigh of relief as they step onto the deck of their recovery ship, the USS Iwo Jima. NASA

on Apollo 8. [On that mission,] I inadvertently punched in the wrong program in the guidance system and had to do a manual realignment. Very, very fortunate, because in Apollo 13, we shut off the command module guidance system. And so we had to realign that guidance system with respect to the stars again so we'd have the proper attitude to come back in with respect to the atmosphere. So something like fate, that comes in handy.

ASTRONOMY: What were the thoughts you had once you splashed down? You must have been incredibly relieved and happy.

LOVELL: Yeah, I was incredibly relieved to think that we got back. And then I thought to myself as I was bobbing around and before I got out of the spacecraft — you know we are kind of fortunate because if that explosion had occurred just after we committed ourselves to that high velocity to go to the Moon, we would never have had enough electrical power to get all the way home again. We would have been out of electrical power. And if that explosion had occurred after we got into lunar orbit or Fred and I were on the lunar surface and came up, we'd never have enough fuel to get out of lunar orbit and to get back home again. So if we had to have an explosion on the way to the Moon, that was the time to have it.



Jim Lovell reads a newspaper account of the Apollo 13 recovery efforts on board the USS Iwo Jima. NASA

ASTRONOMY: One final question I have on a somewhat lighter note. What was the experience like of being in the film *Apollo 13* and appearing in it, as well as your association with the making of the film?

LOVELL: With respect to the movie, I enjoyed being in it. It was a cameo spot. Actually, [the director] Ron Howard came up to me and said, "Would you want to be the admiral?" There was an admiral on board the regular ship. I said, "No, I retired as a captain — I'll dig out my old uniform, and I'll look at the ribbons that he had, and I'll put those on." So it duplicated him, and that's the way we'll go. ☺



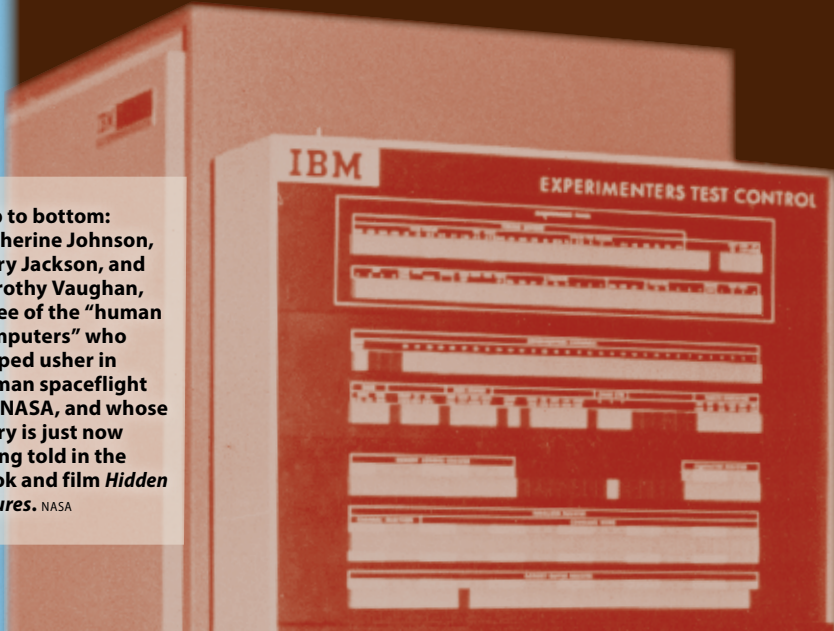
TO SEE AN EXTENDED VIDEO OF ASTRONOMY'S INTERVIEW WITH JIM LOVELL, VISIT www.Astronomy.com

Fighting FOR Visibility

From pre-NASA days to Apollo, the struggles of black women in the early space program rarely came to light. Until now.

by Korey Haynes

Top to bottom: Katherine Johnson, Mary Jackson, and Dorothy Vaughan, three of the “human computers” who helped usher in human spaceflight for NASA, and whose story is just now being told in the book and film *Hidden Figures*. NASA



In the heady days of the space race, the Mercury Seven astronauts were celebrities, and the Moon’s silver face seemed, for the first time in human existence, close enough to touch. For many, space was a tantalizing promise of a wonderful future, beyond the strife of an increasingly divided Earth. For others, supremacy in space was the answer to the Cold War. And for yet others, space was a sign of profligate spending of time and energy on dreams, when reality desperately needed America’s attention.

NASA achieved its most spectacular first steps in those days, making heroes out of men and women who dared to push harder, dream bigger, and be smarter than anyone before them. Those moments created titans in American history, such as rocket pioneers Robert Goddard and Wernher Von Braun, or astronaut adventurers John Glenn and Neil Armstrong.

But many of the actors in this play remain hidden in the wings. Now, decades after the work that should have made them legendary, the black women who helped put the United States in space are finally having their stories told.

These women, though not the faces memorialized in crowded mission-control room photos or seen waving from catwalks before launching beyond Earth’s grip, were nonetheless stars in their own right. And one of the brightest was Katherine Johnson.

A HUMAN COMPUTER

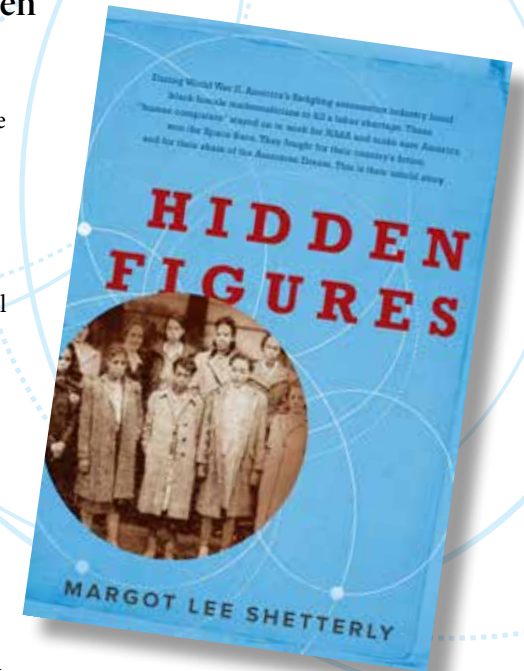
Born in 1918 in White Sulphur Springs, Virginia, Johnson loved numbers as a child. She started college at West Virginia State University at age 15 and blew through the school catalog’s listed courses; her professor created new ones just for her. By 18, she had graduated summa cum laude with degrees in math and French. But career paths for black women were stark in the 1940s, even with a mind as sharp as Johnson’s. She taught school for more than a decade before joining the space race as one of the women, black and white, whom NASA (and its predecessor, the National Advisory Committee for Aeronautics, or NACA) hired as “computers”— people to do the math that kept NASA running.

Korey Haynes is a contributing editor to Astronomy.

When engineers needed to calculate the trajectory for Alan Shepard’s historic suborbital flight, Johnson volunteered. She told the men she worked with exactly where and how to shoot Shepard into the sky so he would splash down safely in range of watchful Navy ships. By the time Glenn orbited Earth, mechanical computers were beginning to replace humans. But Glenn, fearless as he was, wanted his path checked and his life in the hands of someone he could look in the eye, not an unfeeling machine. Johnson was that person, matching the computer decimal for decimal. And when Armstrong, Buzz Aldrin, and Michael Collins left Earth for the Moon, Johnson used the powerful new computers to calculate their trajectory as well. By the time she retired in 1986, she had left her fingerprints on NASA missions from the agency’s first forays beyond Earth into the space shuttle era.

Johnson and her colleagues, Dorothy Vaughan and Mary Jackson, feature prominently in the new book *Hidden Figures*, by Margot Shetterly. The book, which came out in September 2016, is about to hit the big screen as a major motion picture. Johnson is the lead character, played by Taraji P. Henson of the Fox television show *Empire*; Octavia Spencer and Janelle Monáe round out the cast as Vaughan and Jackson, respectively.

Johnson is arguably the most famous of a group of black women Langley Research Center hired to perform calculations during World War II. They were known as the West Computers because they worked in the segregated West Area of Langley. Toiling as brainy beasts of burden, these women — and their white counterparts in the East wing — took math problems parceled out by engineers and solved them with lightning speed and meticulous accuracy.



Women who showed particular skill and interest moved out of the computing pool to work directly with specific engineering groups. This allowed Johnson and others to break free of the physical walls segregating them by race and gender from the rest of the NASA team. Her work earned her NASA achievement awards and landed her in lists of both women’s and African-Americans’ success stories. But her work also landed men on the Moon, and she deserves — and is finally getting — recognition beyond these lesser-known lists. So why are we only hearing her story now?

“She’s almost 98, and she’s still alive and able to tell her own story,” Shetterly says. “A lot of people have passed away, and so she’s around in a moment when we’re looking for people like her. You open the news, and there are a lot of really depressing stories out there. And this is a positive African-American story, it’s a positive female story, it’s a positive American story, it’s a great space story.”

Johnson’s story, in fact, seems



Katherine Johnson sits at her desk, performing the sorts of calculations that eventually led to the Moon landing. NASA



Katherine Johnson receives the Presidential Medal of Freedom for her work ushering in the age of human spaceflight. NASA / BILL INGALLS

almost tailor-made for the big screen. The roots of her computing legacy reach from World War II through the looming threat of the Cold War and the strife and successes of the civil rights movement, hurtling through all of it in the pursuit of space dreams. She was a natural fit in an agency that broke scientific barriers and never stopped asking questions — except that Johnson and her fellow computers were breaking racial as well as scientific ground.

In 2015, President Barack Obama awarded the real Katherine Johnson the Presidential Medal of Freedom. And in May 2016, Langley, where Johnson spent her NASA career, dedicated a building in her name. NASA dedicated the new research facility on the 55th anniversary of Glenn's

victorious return to Earth, but that milestone is only one small piece of the puzzle of “why now?”

“There’s some kind of magic other thing,” Shetterly admits. “I have no idea, but it just is happening of its own accord.”

THE SILVER SCREEN TOUCH

Shetterly is one of the people who has long known not only Johnson’s name, but many women like her. Shetterly grew up in Hampton, Virginia, in Langley’s backyard. Her father worked at Langley as a research scientist. If anything, it took her this long to tell the women’s story because for many years, their work didn’t seem like much of a feat.

“I feel like it was probably one of the greatest gifts in my life just growing up thinking this was normal,” she says. “There was nothing to me that was out of the ordinary about either living in a community with a lot of scientists or living in a community with a lot of African-American scientists or living in a community with a lot of female scientists and engineers and such. It seemed totally normal.”

It wasn’t until Shetterly explained the West Computers to her husband — and witnessed his wonder at their

role in history — that a switch flipped in her mind. She began asking around for the women’s stories and realized there were easily enough to fill a book.

She hadn’t even finished writing that book when film producer Donna Giglotti optioned the rights for a movie, based on only Shetterly’s 50-page book proposal. Screenwriter Allison Schroeder took the proposal and many of Shetterly’s primary source materials and got to work. She focused on three of the women who shine particularly brightly in Shetterly’s research: Johnson, who was central to the leading missions of NASA’s heyday of space flight; Jackson, an energetic young woman who smashed barriers in her advance from computer to engineer; and Vaughan, one of NASA’s first black managers, who ran the segregated West Area Computing Division.

Schroeder was excited to tell the story of these women against the backdrop of the most exciting science program in U.S. history. With grandparents who worked for NASA, and a love of numbers and strong women all her own, Schroeder promises, “I was born to write this.”

But she had her work cut out for her. Unlike the popular *Apollo 13* film — which relied on hours of recorded conversations and minute-by-minute accounts of the event for screenwriters to insert directly into the movie about a single, compact event — scant evidence existed from which *Hidden Figures* could draw.

While Johnson’s work is well preserved in history, she recalls her day-to-day interactions only by memory. And in a story that spans decades — Shetterly’s book opens in the height of World War II and follows

Johnson until her retirement — the movie is obliged to condense multiple historical people into a few characters, the better for the audience to track and connect with. For instance, Kevin Costner plays a character stitched together out of real-life details from multiple flight directors and administrators in NASA’s history.

While the film was never meant to be a documentary, Barry is satisfied that the film will bring the key players and events to life.

“There’s always a balancing act,” says Bill Barry, a NASA historian who worked as a consultant for the film. His team delighted in replicating the halls of Virginia’s Langley Research Laboratory in a disused hospital in Atlanta, right down to the art on the walls. But they were also patient with certain necessary adjustments made in order for the film to tell a cohesive story out of the jumble of real people’s lives.

While the film was never meant to be a documentary, Barry is satisfied that the film will bring the key players and events to life.

A QUESTION OF HISTORY

Another part of the balancing act, not so dissimilar from the question the women themselves contemplated, is how much to talk about the challenges facing three black women in the ’60s, racing for the Moon when so much stood in their way down on Earth.

“We really don’t even deal with race,” observes Henson, who plays Johnson in the movie. “Because you know what was going on in the ’60s. ... We deal with how to rise above it. At the end of the day, how do we get this man on the Moon?”

Barry agrees. “They were focused on the mission,” he says. “So if you had the skill set to do the mission, they put you to work, and who cares about the rules.” But Barry also admits there were rules even NASA wouldn’t break, such as segregated restrooms and a designated cafeteria area.



Left to right: Janelle Monáe as Mary Jackson, Taraji P. Henson as Katherine Johnson, and Octavia Spencer as Dorothy Vaughan in the film *Hidden Figures*, based on the works of the women and their colleagues in the early space program. 20TH CENTURY FOX

Duchess Harris, a professor of American studies at Macalester College, argues, “That’s not meritocracy.” Harris has written her own book about the West Area computers, *Hidden Human Computers*. Like Shetterly, she has a personal connection to these women: Miriam Daniel Mann, one of the Langley computers, was her grandmother. She points out that the land Langley stands on was, until 1950, a plantation. While NASA extended science jobs to black employees, the segregation of the times meant race was still a constant presence in their lives.

Many NASA employees took classes

to extend their already advanced technical knowledge, but African-Americans were forbidden from many of the local colleges because of segregation laws. The nearby Hampden Institute, a well-respected black university, supplied much of the desired coursework. Compounding the problem, NASA’s standard position for hiring women was as a computer — a subprofessional position that paid half an engineer’s salary, even for men and women with identical degrees. While NASA gave a few black women an important foothold, the deck was very much stacked against them.

But Henson is convinced that the film doesn’t need to discuss race — or gender — to make powerful statements about representation. “As I’m doing my research,” she recalls, “I see all of this NASA footage, and I don’t see any women, not even white women. There was a west wing of computing and an east wing of computing, and they’re just erased from history. ... It blows my mind that little girls don’t know that they can do this.”

THE SPACE WOMEN OF TOMORROW

Spreading the women’s message is both an important first step, and an incredibly rewarding one. Many hope that seeing Johnson on the big screen will trumpet her name far beyond NASA write-ups and awards.

But the Hollywood story, and even



In another still from the film *Hidden Figures*, the human computers gather around a screen during an important space launch. 20TH CENTURY FOX

OTHER IMPORTANT FIGURES EMERGING FROM HISTORY'S SHADOW



Miriam Daniels Mann was hired at the same time as Dorothy Vaughan, in 1943. Refusing the indignity of segregation in her supposedly enlightened workplace, Mann stole the signs marking the “colored” section of the cafeteria for years. Her granddaughter, Duchess Harris, is now researching the stories of all the West Computers. DEWITT WALLACE

LIBRARY AT MACCALASTER COLLEGE



One of the younger computers, Christine Darden began working at NASA in 1967. She rose to the title of engineer in 1973, one of the few women of any color at the time to hold that position. Since then, she has published more than 50 papers and is recognized as a world expert in sonic booms. NASA



Dorothy Vaughan sits with Leslie Hunter and Vivian Adair (left to right); all three women worked as human computers. NASA

Shetterly’s more in-depth book, are only narrow peeks into the rich history of the women who provided the bedrock of NASA’s endeavors. Last year, Nathalia Holt released *Rise of the Rocket Girls*, about the women of the Jet Propulsion Laboratory, whose calculations guaranteed the success of rocket flights and planetary missions. Holt credits their legacy to JPL’s retaining more women-powered space teams than elsewhere in the NASA family, where female team leads are hard to come by. But her book tells the story of only one center and its largely white team. Elsewhere, black women struggled up a steeper hill.

Harris continues her own study of the women of Langley, her research finding a home in museums and classrooms instead of in popular media. She hopes targeting children with these women’s stories will provide role models for kids who often don’t see scientists who look like them.

Speaking for NASA, Barry agrees. “We hope [the *Hidden Figures* film] encourages more young people to go into the field. From our perspective, there’s lots of fallout benefits from telling this kind of story.”

Those benefits are desperately needed. The space science fields, engineering in particular, suffer acutely from a lack of women and minorities. While the earliest computer programmers were exactly these human computers of NASA — adapting their math from pencil and paper and

bulky calculator to computer punch cards — women’s participation in computing fields flagged as the field advanced. And less than a hundred African-American women have earned Ph.D.s in physics. Ever.

The reasons for this are manifold and complex, but it is a self-perpetuating problem. With so few black women in these fields, even those who complete advanced degrees can feel unwelcome at their work and find themselves treading ground not so dissimilar from Johnson’s days, the social barriers less visible but still extant. And seeing few black women in those workspaces can discourage young potential scientists, who see no one like themselves to whom they can aspire.

Chanda Prescod-Weinstein, a professor of physics at the University of Washington, counts herself among the few black women with physics Ph.D.s. “Our institutional bias against black women scientists is so strong that it is literally hard for people to imagine I exist,” she says. “I overcame it. The people who hired me overcame it.”

She points to the “nonlinearity” of progress in STEM diversity. (STEM refers to the disciplines in science, technology, engineering, and math.) While Johnson and the other *Hidden Figures* characters worked in a team with other black women, Prescod-Weinstein says that she was 13 years into her research before she found the chance to



Melba Roy Mouton, pictured next to an electronic computer, was the leader of a group of human computers who helped track Echo satellites in the early 1960s. NASA

work with another woman on a project.

“This film offers us an opportunity to really reflect on how science was done then, and why community took the structure it did, including the fact that because of segregation, sometimes it was easier for people to create community because they were forced into it,” she says. “Now the segregation is less visible or less present, but I think a lot of times just less visible, and it can be harder for people to find community.”

Studies show that as early as middle school, girls and minorities are opting out of science not because they enjoy it less or even see themselves as less capable, but because they don’t see science as something that is for them.

Understanding that not only can black women excel in space science, but they have been doing so all along, could make a huge impact on the next generation of scientists. “It really highlights the importance of not separating the science from the history of how it was produced,” Prescod-Weinstein says.

FOR THE GREATER GOOD

It’s also noteworthy that the human computers’ stories center not on one lone genius, but on brilliant women who were part of a team. Science is often seen as a lone wolf endeavor, idealizing individuals like Albert Einstein or Stephen Hawking. But NASA has always been about team efforts.

Studies show that women are drawn to jobs that foster cooperation and have a clear impact, and that physics’ reputation for cold calculation turns many of them off at young ages. It is not just the faces of Langley’s human computers that are important, but the ways in which they did their jobs.

“Somebody wants to know something,” said the 98-year-old Johnson, explaining her math skills in a speech at her own Langley dedication ceremony. “Help them. Help anybody you can help.” She saw her love of math as a way to further America’s dreams. After her retirement, she spent

decades traveling to classrooms and meeting school groups, encouraging more women to follow in her footsteps.

“She would always include other people,” says Henson, who has come not only to admire, but to adore the woman she portrays. “Because she knows it’s teamwork. But it was her calculations.”

“If you’ve done an answer to a problem ... yours is the answer,” Johnson said in her dedication ceremony. And she is proud of her years of service: “When they pulled out a few notes to write down what I had worked on, the guy had 20 pages.”

Johnson said she was pleased to see the emerging pattern of recognizing women’s work, something she says men have long gotten credit for.

Prescod-Weinstein anticipates the film as “an opportunity to write history correctly, finally, about what has been the nature of black contributions to American intellectual history.”

For many reasons, the West Computers’ names are never likely to rise to the level of Neil Armstrong’s or Jim Webb’s renown. But the solutions were theirs.

Women like Katherine Johnson have always been part of the story. It’s high time we told it. ♻️

“Our institutional bias against black women scientists is so strong that it is literally hard for people to imagine I exist.”

Alan Bean: The artist who walked on the Moon

A NASA astronaut with a passion for art, Bean now brings our satellite down to Earth through his paintings. BY MICHAEL W. MICHELSEN, JR.



Alan Bean served with Pete Conrad and Richard F. Gordon on Apollo 12.

Time can be so unkind to astronauts. After all, after you have been to space, and even walked on the Moon, you might enjoy a short burst of fame — and maybe even a little fortune — then it's over. Buzz Aldrin's appearance on "Dancing with the Stars" notwithstanding, most astronauts retreated to relative obscurity after their NASA days were over. Neil Armstrong became a consultant. In 1970, Michael Collins took a job with the Department of State for a year, then became director of the National Air and Space Museum, and later undersecretary

of the Smithsonian Institution.

But for Alan Bean, the fourth man to walk on the Moon, he took a course that probably few people anticipated. He became an artist.

STILL LIVES TO APOLLO

Even as a youngster, Bean enjoyed art. As a young Navy aviator, Bean took courses in art while stationed for his training at Naval Air Station Patuxent River in Maryland.

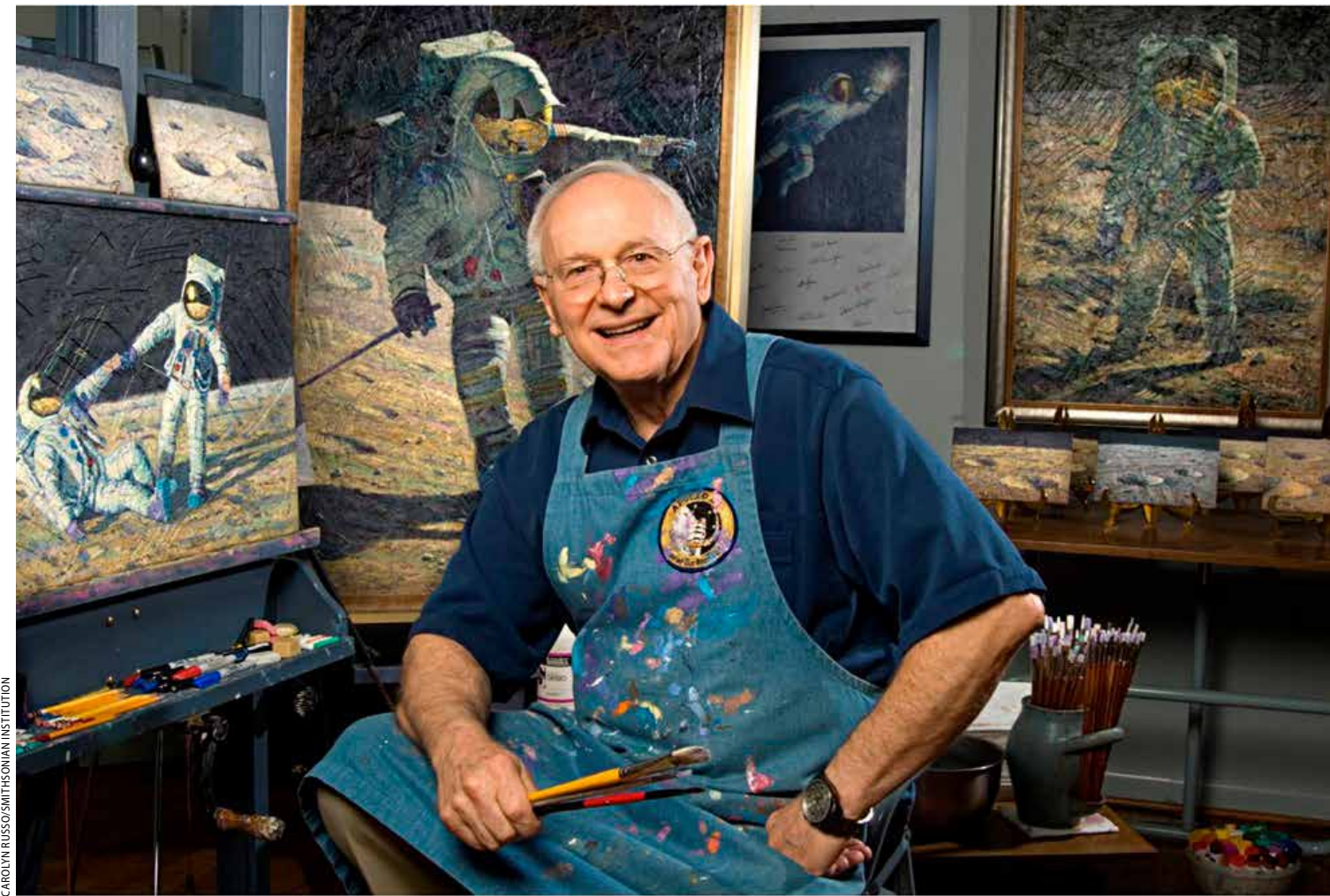
"That was a very busy time for me and my family," Bean explains from his home outside of Houston. "The good part was that as time consuming and strenuous as my flight training was at the time, art served the purpose of centering and relaxing me, whether it was taking art classes or painting still lifes. I loved every minute of it."

Unfortunately, the life of a Naval aviator isn't one that allows a lot of free time, much less time for painting flower arrangements and fruit. As much as Bean enjoyed painting, his Naval duties won out when it came time to make choices.

"Just as is the case with a lot of careers, Naval aviation takes a lot of dedicated time," Bean says. "Then along came the space program, which took my free time down to zero."

Bean served as the lunar module pilot on Apollo 12 the second lunar landing. In November 1969, Bean and Pete Conrad landed on the Moon's Ocean of Storms. They explored the lunar surface, deployed several experiments, and installed the first nuclear power generator station on the moon as a power source. Bean was also the spacecraft commander of Skylab 3, the second manned mission to Skylab, from July 29, 1973, to September 25, 1973.

On his next assignment, Bean served as backup spacecraft commander of the American flight crew for the joint American-Russian Apollo-Soyuz Test Project.



CARDIYN RUSSO/SMITHSONIAN INSTITUTION

PICKING UP HIS BRUSHES AGAIN

Bean ultimately retired from the Navy in October 1975 as a Captain. In 1981, he ended a stint as head of the Astronaut Candidate Operations and Training Group within the Astronaut Office in a civilian capacity.

Fortunately, after his retirement, Bean later decided to renew his interest in art to, as he puts it, "give people the opportunity to see and in a way experience the worlds that I have been fortunate to enjoy."

Unfortunately, to see one of Bean's paintings isn't exactly the same as being there firsthand.

"The Moon is the dreariest, most desolate place I can think of," Bean says. "Fortunately, it's one thing to paint something as it is, but it's quite another to paint something from memory and use it as a tool to teach others."

Bean continues, explaining how he believes his art differs from many other artists: "When I started painting, I could have spent my time painting things here on Earth, and I have on a few occasions, but eventually I decided that those

subjects weren't my niche. That's when I decided to paint the things I knew best: NASA and the space program, particularly Apollo."

ADDING THE MOON TO THE PAINT

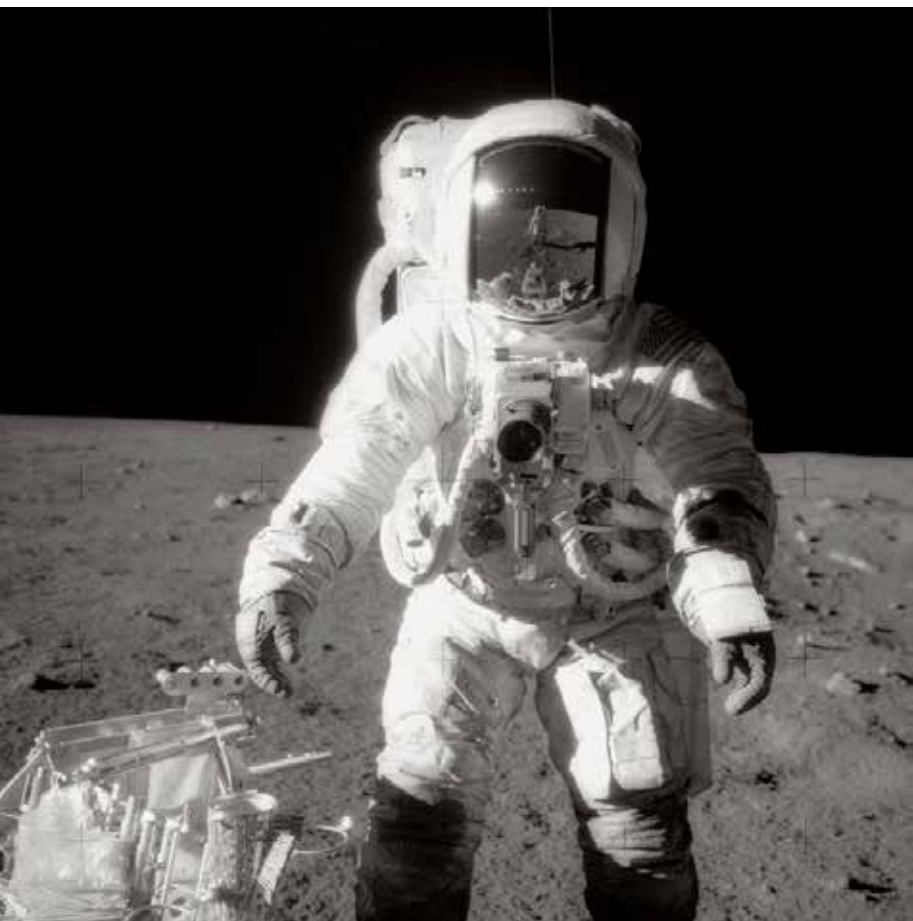
Bean's paintings include using a variety of materials, both as a base as well as a medium. One material that he is particularly proud to use is the result of a few little items he received from NASA after his retirement.

"NASA has a strict policy that everything that belongs to NASA stays with NASA, although all of the astronauts have been able to keep a few mementos from their work," he says.

Among the pieces of space memorabilia Bean managed to keep were the patches from his Moon-worn space suit, his boots, and a single glove. Needless to say, all of these items have made their way into his paintings, in one form or another. And that's putting it lightly.

"As much fun as traipsing around the lunar surface while Pete Conrad and I were doing it," he recalls, "one little matter that nobody thought of

Alan Bean in 2008 with some of his work in his home studio.



Alan Bean on the surface of the Moon during Apollo 12 in 1969. Fellow Moonwalker Pete Conrad is reflected in Bean's helmet as he takes the photo.

creates a nice effect that a lot of people enjoy, and I enjoy doing it.”

MOONWALKER'S FANTASY

When you look at Bean's paintings, you might find yourself wondering if you have parted with reality, since many of the subjects are not true to life, but are part of Bean's imagination. For example, one of his favorites, *The Fantasy*, shows Bean and his fellow Apollo crewmates — Pete Conrad and Richard Gordon — standing on the Moon. For all of his space accomplishments, Gordon never made it to the Moon, but he did in Bean's imagination and his painting.

“This is one of the fun things about being an artist, especially in what I paint,” Bean explains. “If I was a scientist, I would probably paint everything the way it really is, with the Moon, for example, being a dull, monotonous grey, but I'm an artist, so I add color to things to make them more pleasing to look at. For the same reason, I create my fantasy printings as well. They're my fantasy, but they also serve to tell my story about the Apollo program.”

was the fact that we were filthy when we climbed back into the lunar module. We were covered with Moon dust from head to toe, so when I started painting, I decided to make my work special by including scrapings of my patches in the paint I used to create my Apollo paintings.”

LOOKING CLOSER, BUT NOT TOO CLOSE

Looking at a Bean painting is a pleasure, regardless of whether you look at it closely or from far away. Not only will you see the subjects, whether it's a Moonwalker or the scenery, but up close, chances are good that you will notice tiny specs of red, blue, and other colors amongst the paint. These are speckles from the patches that Bean's uniform carried on the lunar surface.

But if you think that the colorful speckles are the only surprise you will see in a Bean painting, you're looking at it too closely, since another treat that often makes its way into a painting are boot prints from the actual suit that Bean wore on the surface. These are best viewed from a distance.

“I use acrylic paints, for the most part,” Bean says. “In some of my paintings, I put one of my space boots on and walk across the surface. It



Tour Apollo's sites through binoculars

“Once in a Blue Moon.” We use this phrase when talking about something that happens on rare occasions. Today, astronomically speaking, the Blue Moon refers to the second Full Moon occurring in the same calendar month. Since there are about 29.5 days between Full

Moons, every now and then the phases will line up so that the full phase will occur on the 1st or 2nd of a month and a second full phase will take place on the 30th or 31st.

Using Universal Time as our measure, June 2007 boasted a Blue Moon. The first Full Moon that month occurred at 1:04 A.M. June 1, while the second happened at 1:49 P.M. June 30. The popular media largely attributed the Blue Moon to May that year, because the June 1 Full Moon actually occurred at 9:04 P.M. EDT May 31, making it the second that month.

Let's celebrate the 2007 Blue Moon (and the Blue Moons that have come after it) with a tour of our neighbor through binoculars.

And in anticipation of the 50th anniversary of Apollo 11's Moon landing in 2019, let's explore the regions where each successful mission to our satellite touched down.

Apollo 11: The dark gray outline of Mare Tranquillitatis (Sea of Tranquility) looks almost perfectly round from our vantage point. The best

time to view Mare Tranquillitatis is during the Moon's waxing crescent phases.

Apollo 12: The mission's landing site lies south of the prominent crater Copernicus, which sees sunrise 2 nights after First Quarter. Watch as sunlight first bathes the crater's sharply defined walls, catching the

strong central mountain peak, before sliding down to the crater floor. Mark your calendar to come back in a few nights when Copernicus' brilliant ray system explodes against the mare's darker background. The starburst pattern is unmistakable through even the most modest binoculars.

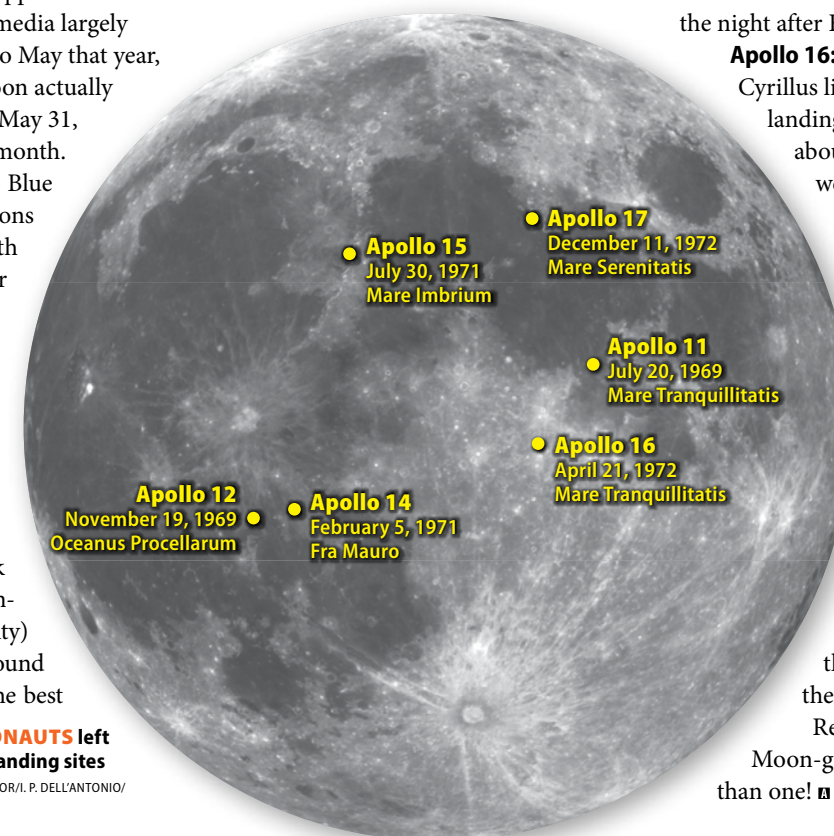
Apollo 14: This mission touched down at the hilly region Fra Mauro, near the southeastern shore of the Ocean of Storms.

Apollo 15: The Apennine Mountains, mark the southeastern edge of Mare Imbrium (Sea of Rains). The Apennines' arc is found just south of a triangle of craters: Aristillus, Autolycus, and Archimedes. All three will lie near the Moon's terminator the night after First Quarter.

Apollo 16: The craters Theophilus and Cyrillus lie to the east (right) of the landing site, while Albategnius is about an equal distance to the west (left). View these features the night before First Quarter. Just west of Albategnius, three more craters — Ptolemaeus, Alphon-sus, and Arzachel — see sunrise the following evening.

Apollo 17: The final Apollo site rests near the Taurus Mountains, forming the eastern rim of Mare Serenitatis (Sea of Serenity). The best time to view the range is during the waxing crescent phases of the month.

Remember, when it comes to Moon-gazing, two eyes are better than one! ■



TWELVE APOLLO ASTRONAUTS left their footprints across six landing sites on the lunar surface. T. A. RECTOR/I. P. DELL'ANTONIO/NOAO/AURA/NSF