1
00:00:00,042 --> 00:00:02,625
(gentle music)

2
00:00:06,150 --> 00:00:09,000
- Hi, I'm Ellen Stofan, or Dr. E.

3
00:00:09,000 --> 00:00:11,230
And I'm the John and
Adrienne Mars Director

4
00:00:11,230 --> 00:00:14,180
of the Smithsonian's National
Air and Space Museum.

5
00:00:14,180 --> 00:00:16,890
- Hey, I'm Thomas Zurbuchen,
also known as Dr. Z.

6
00:00:16,890 --> 00:00:20,180
I'm the Associate Administrator
of Science at NASA.

7
00:00:20,180 --> 00:00:23,030
- So, together, we're "E.Z. Science",

8
00:00:23,030 --> 00:00:26,040
and in each episode, we're
gonna be talking about

9
00:00:26,040 --> 00:00:29,260
what's the latest and
greatest in space science?

10
00:00:29,260 --> 00:00:32,800
Really wanting to cover
exciting topics, what's new,

11
00:00:32,800 --> 00:00:35,840
but also, what have we

learned over these 50 years

12
00:00:35,840 --> 00:00:37,350
of space exploration?

13
00:00:37,350 --> 00:00:41,070
And what better place to start
than with the anniversary

14
00:00:41,070 --> 00:00:43,660
of the landing on the Moon 50 years ago?

15
00:00:43,660 --> 00:00:45,210
- God, I'm so excited to be here,

16
00:00:45,210 --> 00:00:46,900
right here at the museum.

17
00:00:46,900 --> 00:00:48,240
I've been here many times

18
00:00:48,240 --> 00:00:50,410
looking at the exhibit of the Moon.

19
00:00:50,410 --> 00:00:52,230
I think it's one of my absolute favorites

20
00:00:52,230 --> 00:00:54,550
and my favorite museum in the world.

21
00:00:54,550 --> 00:00:55,930
- Yeah, it's an amazing place.

22
00:00:55,930 --> 00:00:58,420
And we do hold the Apollo
collection for the nation,

23
00:00:58,420 --> 00:01:01,610

so it's amazing to be celebrating
this 50th anniversary.

24
00:01:01,610 --> 00:01:03,200
- So, tell us about Apollo.

25
00:01:03,200 --> 00:01:05,710
What are your memories about Apollo?

26
00:01:05,710 --> 00:01:07,030
Your childhood memories?

27
00:01:07,030 --> 00:01:08,240
- So, I was eight years old

28
00:01:08,240 --> 00:01:09,670
the summer we landed on the Moon.

29
00:01:09,670 --> 00:01:11,360
And I remember it really well,

30
00:01:11,360 --> 00:01:13,050
partially 'cause my dad worked for NASA.

31
00:01:13,050 --> 00:01:15,640
So, we were obviously, sort
of, paying attention to it

32
00:01:15,640 --> 00:01:17,090
probably more than most people.

33
00:01:17,090 --> 00:01:19,050
We were up at my grandparents' cottage

34
00:01:19,050 --> 00:01:20,690
on a lake in Michigan.

35
00:01:20,690 --> 00:01:23,250

And my clearest memory was going,

36
00:01:23,250 --> 00:01:25,490
at one point during the night,
we went out onto the lake,

37
00:01:25,490 --> 00:01:27,510
and it was a fairly sizable lake.

38
00:01:27,510 --> 00:01:31,200
And you could hear the broadcast echoing

39
00:01:31,200 --> 00:01:33,350
all over the lake, because that night,

40
00:01:33,350 --> 00:01:35,040
you know, not just America stood still,

41
00:01:35,040 --> 00:01:37,480
but the world stood still to watch

42
00:01:37,480 --> 00:01:39,430
what humanity was accomplishing.

43
00:01:39,430 --> 00:01:40,840
Frankly, when they landed on the Moon,

44
00:01:40,840 --> 00:01:42,790
those really fuzzy
images, and by that point,

45
00:01:42,790 --> 00:01:44,140
it was after 11 o'clock at night,

46
00:01:44,140 --> 00:01:46,120
and I was eight years
old, I was really tired.

47

00:01:46,120 --> 00:01:47,920
So that part I remember
a little less clearly.

48
00:01:47,920 --> 00:01:49,510
- Yeah, it's really amazing.

49
00:01:49,510 --> 00:01:50,780
I can only imagine.

50
00:01:50,780 --> 00:01:55,130
For me, Apollo has really changed my life.

51
00:01:55,130 --> 00:01:57,140
The university where I got my Ph.D.

52
00:01:57,140 --> 00:01:59,530
and was the university that, in a group,

53
00:01:59,530 --> 00:02:03,580
that was started because
of the first experiment

54
00:02:03,580 --> 00:02:06,660
on the surface of the Moon,
the solar wind experiment.

55
00:02:06,660 --> 00:02:09,580
The work I did afterwards
was robotic exploration

56
00:02:09,580 --> 00:02:13,760
with NASA spacecraft as a
followup of that experiment

57
00:02:13,760 --> 00:02:16,998
that was set up by Buzz Aldrin
right after the landing.

58

00:02:16,998 --> 00:02:19,610
- You know, a lot of people
throughout my career have said,

59
00:02:19,610 --> 00:02:22,210
what did we learn from all
those Apollo moon rocks

60
00:02:22,210 --> 00:02:24,320
they brought back, one
of which you can touch

61
00:02:24,320 --> 00:02:26,570
right here at the Air and Space Museum,

62
00:02:26,570 --> 00:02:29,030
what did we learn from
all those Apollo rocks?

63
00:02:29,030 --> 00:02:33,090
For you, what are the big
science takeaways from Apollo?

64
00:02:33,090 --> 00:02:35,780
- So, for me, what's
really the most amazing

65
00:02:35,780 --> 00:02:37,330
is, I think, when I look at the Moon,

66
00:02:37,330 --> 00:02:39,710
and I do that every
time I get a chance to.

67
00:02:39,710 --> 00:02:42,330
It's just amazing, this
celestial neighbor of ours,

68
00:02:42,330 --> 00:02:43,350
looking at it.

69
00:02:43,350 --> 00:02:46,140
I think of it as kind of
the archives of the earth

70
00:02:46,140 --> 00:02:47,750
and the solar system history.

71
00:02:47,750 --> 00:02:50,740
What we learn about is really
the bombardment history

72
00:02:50,740 --> 00:02:54,350
of the solar system, but also,
about really the relationship

73
00:02:54,350 --> 00:02:56,800
between the Earth and the Moon.

74
00:02:56,800 --> 00:02:57,780
But how 'bout you?

75
00:02:57,780 --> 00:02:59,830
- Well, you know, it's really
that, going back to the fact

76
00:02:59,830 --> 00:03:02,100
that all those impact craters
on the Moon that you see,

77
00:03:02,100 --> 00:03:03,540
those big, huge circles on the Moon,

78
00:03:03,540 --> 00:03:04,780
they're telling you at some point,

79
00:03:04,780 --> 00:03:07,330
all those bodies were
also hitting the Earth

80
00:03:07,330 --> 00:03:09,480
and creating huge craters on the Earth,

81
00:03:09,480 --> 00:03:13,000
but with the Earth surface
constantly changing over time,

82
00:03:13,000 --> 00:03:15,190
we've lost that early
history of the Earth.

83
00:03:15,190 --> 00:03:17,020
So, we can go to the Moon and say,

84
00:03:17,020 --> 00:03:19,430
what was the Earth like
four billion years ago?

85
00:03:19,430 --> 00:03:22,490
And really help to learn
more about this planet.

86
00:03:22,490 --> 00:03:26,271
And of course, there are theories
that the Moon originated,

87
00:03:26,271 --> 00:03:28,750
started out as a big chunk of
the Earth that got knocked out

88
00:03:28,750 --> 00:03:32,120
by a very large impact
early in Earth's history.

89
00:03:32,120 --> 00:03:35,810
So, understanding what was that
lost chemistry, so to speak,

90

00:03:35,810 --> 00:03:37,530
of that chunk of the
Earth that got removed

91
00:03:37,530 --> 00:03:40,460
is also really important for
understanding this planet.

92
00:03:40,460 --> 00:03:42,800
- You know, one of the things
that's been really amazing,

93
00:03:42,800 --> 00:03:43,900
these rocks that came back,

94
00:03:43,900 --> 00:03:45,650
one of the rocks you have right here,

95
00:03:45,650 --> 00:03:49,600
have really been a source
of science even to today.

96
00:03:49,600 --> 00:03:51,870
Early next year, we're opening up

97
00:03:51,870 --> 00:03:55,200
one of the Apollo cores
that we've never opened up.

98
00:03:55,200 --> 00:03:56,980
And there's still a lot
of science we're learning.

99
00:03:56,980 --> 00:03:59,390
What are the most, kind
of, recent science results

100
00:03:59,390 --> 00:04:00,437
that are exciting to you?

101
00:04:00,437 --> 00:04:02,810
- You know, a lot of it
really does have to do

102
00:04:02,810 --> 00:04:05,640
with this history of the
Moon and what it's telling us

103
00:04:05,640 --> 00:04:08,187
about the long-term history of the Earth,

104
00:04:08,187 --> 00:04:12,170
but for a lot of us who really
care about how we move humans

105
00:04:12,170 --> 00:04:15,810
out into the solar system,
we think about things like,

106
00:04:15,810 --> 00:04:17,210
could there be ice on the Moon?

107
00:04:17,210 --> 00:04:19,390
Could there be any ice deposits

108
00:04:19,390 --> 00:04:22,370
that future astronauts could maybe access?

109
00:04:22,370 --> 00:04:24,930
And so, the fact that, over
the last, about, decade,

110
00:04:24,930 --> 00:04:27,750
with various instruments, we've
actually been figuring out

111
00:04:27,750 --> 00:04:29,330
there are ice deposits on the Moon.

112
00:04:29,330 --> 00:04:31,130
There's ice in the lunar soil.

113
00:04:31,130 --> 00:04:33,450
There could be, actually,
larger ice deposits

114
00:04:33,450 --> 00:04:35,190
in permanently-shadowed craters

115
00:04:35,190 --> 00:04:36,980
that are at the poles of the Moon.

116
00:04:36,980 --> 00:04:39,560
And so, this idea of water
on the Moon, which certainly,

117
00:04:39,560 --> 00:04:41,410
at Apollo, we didn't
think that was possible,

118
00:04:41,410 --> 00:04:43,310
we've really learned in the last decade.

119
00:04:43,310 --> 00:04:45,600
And again, why that's
important is for one thing,

120
00:04:45,600 --> 00:04:47,560
that water is probably cometary ice.

121
00:04:47,560 --> 00:04:48,840
And we're interested in comets,

122
00:04:48,840 --> 00:04:50,770
'cause they helped form the Earth,

123
00:04:50,770 --> 00:04:52,650

but we're also really
interested in using it

124
00:04:52,650 --> 00:04:54,380
potentially as a resource.

125
00:04:54,380 --> 00:04:56,820
- And of course, that's
why, as early as 2020,

126
00:04:56,820 --> 00:04:59,540
we're going back with robots,

127
00:04:59,540 --> 00:05:02,430
initially in kind of an equatorial region,

128
00:05:02,430 --> 00:05:04,610
but soon enough to the polar regions,

129
00:05:04,610 --> 00:05:06,420
and then as early as '24,

130
00:05:06,420 --> 00:05:08,150
with humans to the very same region,

131
00:05:08,150 --> 00:05:09,880
because the resources are right there.

132
00:05:09,880 --> 00:05:11,840
Those water resources, we think,

133
00:05:11,840 --> 00:05:13,960
from remote sensing, are right there.

134
00:05:13,960 --> 00:05:16,030
- So, what are all the missions
that are going on right now?

135

00:05:16,030 --> 00:05:17,580
I know there's a lot going on right now.

136
00:05:17,580 --> 00:05:18,580
In fact, there's so much going on,

137
00:05:18,580 --> 00:05:19,640
I can barely keep track of it.

138
00:05:19,640 --> 00:05:22,240
I know you just recently
announced a bunch of ideas

139
00:05:22,240 --> 00:05:23,950
of missions going back to the Moon.

140
00:05:23,950 --> 00:05:26,220
- So, what's really exciting to me,

141
00:05:26,220 --> 00:05:29,860
besides the Moon being a really
important science target,

142
00:05:29,860 --> 00:05:31,660
it's also a way station to Mars.

143
00:05:31,660 --> 00:05:33,700
What we're really doing right now

144
00:05:33,700 --> 00:05:35,760
is we're develop technology instruments.

145
00:05:35,760 --> 00:05:38,670
And right now, we're working
on 28 science instruments

146
00:05:38,670 --> 00:05:40,380
and tech demonstrations.
- 28?

147
00:05:40,380 --> 00:05:42,070
- And the way we're flying them there

148
00:05:42,070 --> 00:05:44,010
is using commercial partners.

149
00:05:44,010 --> 00:05:44,970
So, we can do that.

150
00:05:44,970 --> 00:05:47,557
We can use a very different
development paradigm for that,

151
00:05:47,557 --> 00:05:48,860
but of course, in parallel,

152
00:05:48,860 --> 00:05:50,800
our colleagues from human exploration

153
00:05:50,800 --> 00:05:53,000
are developing the systems both to get,

154
00:05:53,000 --> 00:05:55,760
with a big rocket, off
the surface of the Earth,

155
00:05:55,760 --> 00:05:58,630
but also then, this small gateway,

156
00:05:58,630 --> 00:06:01,050
kind of a small station that is there,

157
00:06:01,050 --> 00:06:03,323
really, as a place to learn to live away

158
00:06:03,323 --> 00:06:04,540
from Earth gravity,

159
00:06:04,540 --> 00:06:06,951
learn to live away from
the Earth magnetic field.

160
00:06:06,951 --> 00:06:10,180
And then, to the surface
with commercial partners.

161
00:06:10,180 --> 00:06:12,530
- So, I love this idea that
we have this huge legacy

162
00:06:12,530 --> 00:06:15,020
of Apollo that's really carried us forward

163
00:06:15,020 --> 00:06:17,360
from all the science we
learned from Apollo early on

164
00:06:17,360 --> 00:06:19,450
to the new science
we're doing at the Moon,

165
00:06:19,450 --> 00:06:22,310
a lot of it helping us not
understand more about this planet

166
00:06:22,310 --> 00:06:24,380
but also where we go next.

167
00:06:24,380 --> 00:06:25,920
And it's gonna be that stepping stone

168
00:06:25,920 --> 00:06:28,370
to exploring the rest of our solar system.

169
00:06:28,370 --> 00:06:30,640
- I really believe that's one

of the most important aspects

170
00:06:30,640 --> 00:06:32,260
for Apollo for me.

171
00:06:32,260 --> 00:06:33,910
It shows that we can do these things.

172
00:06:33,910 --> 00:06:35,160
We go beyond.

173
00:06:35,160 --> 00:06:36,670
Yes, the Moon is there.

174
00:06:36,670 --> 00:06:38,350
Yes, we're celebrating it.

175
00:06:38,350 --> 00:06:40,050
But our aspirations are beyond.

176
00:06:40,050 --> 00:06:43,740
We can't wait to have the
United States on the surface

177
00:06:43,740 --> 00:06:45,360
with our international
and commercial partners

178
00:06:45,360 --> 00:06:47,050
on the surface of Mars.

179
00:06:47,050 --> 00:06:51,290
We can't wait to see
Dragonfly, this new mission,

180
00:06:51,290 --> 00:06:53,470
that we just selected to go to Titan.

181

00:06:53,470 --> 00:06:55,540
What are the most exciting things for you

182
00:06:55,540 --> 00:06:57,320
on the outside of the Moon?

183
00:06:57,320 --> 00:07:00,400
- Yeah, for me, it's really
getting humans to Mars,

184
00:07:00,400 --> 00:07:03,170
breaking open that bright
rock, and finding out

185
00:07:03,170 --> 00:07:04,950
did life evolve on the red planet?

186
00:07:04,950 --> 00:07:07,820
And what can we learn from that
about how life evolved here?

187
00:07:07,820 --> 00:07:09,210
And then, going out to those moons

188
00:07:09,210 --> 00:07:12,450
in the outer solar system,
Titan, Enceladus, Europa,

189
00:07:12,450 --> 00:07:15,570
and really searching to say,
is there life beyond Earth?

190
00:07:15,570 --> 00:07:17,590
There's so much going on.

191
00:07:17,590 --> 00:07:19,717
- We're just about out
of time, unfortunately.

192

00:07:19,717 --> 00:07:22,450
Really enjoying talking to you.

193
00:07:22,450 --> 00:07:25,110
- This has been really fun,
but in future episodes,

194
00:07:25,110 --> 00:07:27,960
what we'd like to do is to have
you send us your questions.

195
00:07:27,960 --> 00:07:31,340
So, contact us on social
media, on Twitter, on Facebook,

196
00:07:31,340 --> 00:07:35,110
and let us know what you
would like to learn about.

197
00:07:35,110 --> 00:07:37,237
- So, we'll see each
other again at the next