
2022
GODDARD
SUMMER FILM FESTIVAL

1
00:00:00,000 --> 00:00:01,634
"Goddard Space Flight Center presents"

2
00:00:01,634 --> 00:00:02,335
Hey, everyone,

3
00:00:02,335 --> 00:00:04,104
welcome to Snack Time with NASA.

4
00:00:04,104 --> 00:00:05,805
I'm your host, Kathleen Gaeta.

5
00:00:05,805 --> 00:00:08,675
■■■

6
00:00:08,675 --> 00:00:11,011
And liftoff from a tropical rainforest

7
00:00:11,011 --> 00:00:13,179
to the edge of time itself.

8
00:00:13,179 --> 00:00:13,580
That's like

9
00:00:13,580 --> 00:00:15,415
looking through the eye of a needle,

10
00:00:15,415 --> 00:00:17,283
and in that tiny space.

11
00:00:17,283 --> 00:00:20,553
we found 10,000 galaxies.

12
00:00:20,553 --> 00:00:23,189
■■■

13
00:00:23,189 --> 00:00:25,291

That fusion creates a tremendous amount

14
00:00:25,291 --> 00:00:27,127
of energy, and is literally

15
00:00:27,127 --> 00:00:30,930
what fuels a star and makes the light we see.

16
00:00:31,598 --> 00:00:35,168
We're studying the deaths of islands.

17
00:00:35,168 --> 00:00:38,671
Islands that spring forth from volcanism.

18
00:01:00,493 --> 00:00:58,224
■■■

19
00:01:00,493 --> 00:01:07,967
"OSIRIS-REx Sheds Light on Hazardous Asteroid Bennu"
Dan Gallagher, Producer; Josh Masters, Animator

20
00:01:09,702 --> 00:01:08,935
■■■

21
00:01:09,702 --> 00:01:13,807
In 2135, a potentially hazardous asteroid called Bennu

22
00:01:13,807 --> 00:01:15,942
will make a close flyby of Earth.

23
00:01:15,942 --> 00:01:19,546
During this encounter, our planet’s gravity will tweak Bennu’s path,

24
00:01:19,546 --> 00:01:22,482
making it a challenge to calculate its future trajectory

25
00:01:22,482 --> 00:01:26,386
and the odds of a potential impact late in the 22nd century.

26
00:01:26,386 --> 00:01:28,221
Why is this hard to determine?

27
00:01:28,221 --> 00:01:30,423
Well, we know how gravity works…

28
00:01:30,423 --> 00:01:32,892
but there are still uncertainties in Bennu’s trajectory

29
00:01:32,892 --> 00:01:35,528
that will be magnified by the close encounter.

30
00:01:35,528 --> 00:01:38,431
In addition to gravity, asteroids can be pushed around

31
00:01:38,431 --> 00:01:42,102
by non-gravitational forces like the Yarkovsky effect.

32
00:01:42,102 --> 00:01:46,172
When sunlight strikes a rotating asteroid, the dayside heats up.

33
00:01:46,172 --> 00:01:49,209
As the asteroid turns, the night side cools down

34
00:01:49,209 --> 00:01:50,743
and releases the heat.

35
00:01:50,743 --> 00:01:53,213
This exerts a small thrust on the asteroid,

36
00:01:53,213 --> 00:01:55,849
which can change its direction over time.

37
00:01:55,849 --> 00:01:58,718
The Yarkovsky effect is challenging to model, but it can make

38

00:01:58,718 --> 00:02:02,088
a big difference in determining where asteroids end up.

39
00:02:02,088 --> 00:02:04,924
Because we don’t know exactly how the Yarkovsky effect

40
00:02:04,924 --> 00:02:07,460
will perturb Bennu’s orbit, we have limited knowledge

41
00:02:07,460 --> 00:02:11,564
of where Bennu will be as it approaches Earth in 2135.

42
00:02:11,564 --> 00:02:15,602
Scientists thus have to consider a range of possible trajectories,

43
00:02:15,602 --> 00:02:19,472
depending on how strongly the Yarkovsky effect is pushing on Bennu.

44
00:02:19,472 --> 00:02:22,675
A few of these trajectories line up with regions of space

45
00:02:22,675 --> 00:02:25,345
called gravitational keyholes.

46
00:02:25,345 --> 00:02:27,580
If Bennu were to pass through a keyhole,

47
00:02:27,580 --> 00:02:30,817
Earth’s gravity would bend its path in just the right way

48
00:02:30,817 --> 00:02:33,153
to cause an impact on a subsequent orbit,

49
00:02:33,153 --> 00:02:35,421
late in the 22nd century.

50
00:02:35,421 --> 00:02:38,424
The odds of this actually happening are quite low,

51
00:02:38,424 --> 00:02:41,261
but scientists want to know as much as possible.

52
00:02:41,261 --> 00:02:44,697
That’s one reason why NASA sent the OSIRIS-REx spacecraft

53
00:02:44,697 --> 00:02:48,234
to study Bennu from 2018 to 2021.

54
00:02:48,234 --> 00:02:51,171
OSIRIS-REx greatly improved our knowledge of Bennu’s

55
00:02:51,171 --> 00:02:54,674
position, density, thermal inertia, and other properties

56
00:02:54,674 --> 00:02:58,077
that can influence how its orbit will evolve over time.

57
00:02:58,077 --> 00:03:00,847
The new data allowed scientists to significantly reduce

58
00:03:00,847 --> 00:03:03,283
uncertainties in Bennu’s predicted orbit,

59
00:03:03,283 --> 00:03:06,653
ruling out a number of keyholes for the 2135 flyby,

60
00:03:06,653 --> 00:03:10,089
and eliminating several future impact scenarios.

61
00:03:10,089 --> 00:03:13,259
While Bennu remains a hazardous asteroid, we can now make

62
00:03:13,259 --> 00:03:17,230
better models of its orbital evolution thanks to OSIRIS-REx.

63

00:03:17,230 --> 00:03:19,666
This will allow us – and our descendants –

64
00:03:19,666 --> 00:03:21,601
to better calculate Bennu’s risk

65
00:03:21,601 --> 00:03:23,903
in the decades and centuries to come.

66
00:03:23,903 --> 00:03:26,940
■■■

67
00:03:26,940 --> 00:03:32,345
"Visions of the Future"
Chris Smith, Producer

68
00:03:32,345 --> 00:03:34,214
■■■

69
00:03:34,214 --> 00:03:38,685
[music throughout]

70
00:03:38,685 --> 00:03:43,223
"The Moon"

71
00:03:43,223 --> 00:03:50,330
"Mars"

72
00:03:50,330 --> 00:03:56,369
"Venus"

73
00:03:56,369 --> 00:04:02,275
"Titan"

74
00:04:02,275 --> 00:04:06,279
"Enceladus"

75
00:04:06,279 --> 00:04:14,587

"Exoplanet HD 40307g"

76
00:04:14,587 --> 00:04:22,295
"Exoplanet Kepler-16b"

77
00:04:22,295 --> 00:04:30,370
"Exoplanet 55 CANCRI e"

78
00:04:30,370 --> 00:04:38,311
"Exoplanet GJ 357 d"

79
00:04:38,311 --> 00:04:40,980
"Where will you explore?"

80
00:04:40,980 --> 00:04:42,815
"Start your journey."

81
00:04:42,815 --> 00:04:45,485
exoplanets.nasa.gov/travel

82
00:04:45,485 --> 00:04:47,086
■■■

83
00:04:47,086 --> 00:04:52,091
"Pinpointing the Moon's South Pole"
David Ladd, Producer; Ernest Wright, Visualizer

84
00:04:52,091 --> 00:04:54,927
■■■

85
00:04:54,927 --> 00:04:56,829
In order for NASA to map and explore

86
00:04:56,829 --> 00:04:59,265
the region around the lunar South Pole,

87
00:04:59,265 --> 00:05:01,267
we need to precisely define a system of

88
00:05:01,267 --> 00:05:03,536
latitude and longitude on the Moon,

89
00:05:03,536 --> 00:05:07,006
including the exact location of the South Pole itself.

90
00:05:08,374 --> 00:05:09,442
In the coordinate system

91
00:05:09,442 --> 00:05:12,278
adopted by the Lunar Reconnaissance Orbiter mission,

92
00:05:12,278 --> 00:05:13,980
the South Pole is here,

93
00:05:13,980 --> 00:05:16,482
on the rugged rim of Shackleton crater.

94
00:05:16,482 --> 00:05:20,753
■■■

95
00:05:20,753 --> 00:05:22,822
If you stood on this treacherous spot,

96
00:05:22,822 --> 00:05:24,891
you’d see the sunlit rim of the crater,

97
00:05:24,891 --> 00:05:27,193
encircling a permanently shadowed abyss

98
00:05:27,193 --> 00:05:29,128
that’s two and a half miles deep,

99
00:05:29,128 --> 00:05:31,297
over twice that of the Grand Canyon,

100

00:05:31,297 --> 00:05:34,300
covering an area over 130 square miles.

101
00:05:36,402 --> 00:05:38,571
As we return to the lunar surface,

102
00:05:38,571 --> 00:05:39,872
three dimensional maps like this

103
00:05:39,872 --> 00:05:42,642
will help guide astronauts to safe landing sites

104
00:05:42,642 --> 00:05:46,212
in the challenging landscape of the Moon’s South Pole.

105
00:05:46,212 --> 00:05:51,417
■■■

106
00:05:51,417 --> 00:05:51,617
Earth Resources Technology Satellite,

107
00:05:51,617 --> 00:05:58,024
"A Trip Through Time with Landsat 9" Matt Radcliff, Producer;
Jenny McElligott, Animator; Alexander Bodnar, Animator

108
00:05:58,024 --> 00:05:59,926
■■■

109
00:05:59,926 --> 00:06:02,495
From 438 miles above Earth’s surface,

110
00:06:02,495 --> 00:06:06,466
the newest Landsat satellite will collect data so detailed,

111
00:06:06,466 --> 00:06:07,934
it can detect both natural and

112
00:06:07,934 --> 00:06:10,169

human-caused changes to the landscape.

113
00:06:10,169 --> 00:06:12,305
■■■

114
00:06:12,305 --> 00:06:14,040
But what really makes Landsat unique

115
00:06:14,040 --> 00:06:16,109
is the half-century of data,

116
00:06:16,109 --> 00:06:19,645
an unbroken chain of observations over five decades.

117
00:06:19,645 --> 00:06:21,981
Let’s take a look at how we got here.

118
00:06:22,181 --> 00:06:25,418
1966 – The US Geological Survey proposes a satellite

119
00:06:25,418 --> 00:06:27,553
to study Earth’s land masses.

120
00:06:27,553 --> 00:06:29,389
But what would that look like?

121
00:06:29,389 --> 00:06:30,690
Over the next few years,

122
00:06:30,690 --> 00:06:34,227
USGS and NASA research their options.

123
00:06:34,227 --> 00:06:35,595
■■■

124
00:06:35,595 --> 00:06:38,998
1970 – NASA gets the green light to build

125
00:06:38,998 --> 00:06:41,401
an Earth Resources Technology Satellite,

126
00:06:41,401 --> 00:06:43,336
an experiment to study and monitor

127
00:06:43,336 --> 00:06:45,938
our planet’s land surface from space.

128
00:06:45,938 --> 00:06:47,440
Launched in ’72,

129
00:06:47,440 --> 00:06:50,109
this was the first digital data of Earth,

130
00:06:50,109 --> 00:06:53,079
repeated at regular intervals, with geometric fidelity

131
00:06:53,079 --> 00:06:56,582
to allow comparison between observations.

132
00:06:57,383 --> 00:06:59,185
This changed how we drew maps,

133
00:06:59,185 --> 00:07:01,254
tabulated agricultural production,

134
00:07:01,254 --> 00:07:03,890
and assessed damage after disasters.

135
00:07:04,323 --> 00:07:07,293
In 1975, NASA launched a second satellite,

136
00:07:07,293 --> 00:07:09,028
similar to the first.

137
00:07:09,028 --> 00:07:12,031

Now they were collecting twice as much data.

138
00:07:12,031 --> 00:07:15,468
With Landsat 3 replacing the aging original in ’78,

139
00:07:15,468 --> 00:07:19,272
focus shifted to the advanced technology planned for the 80s.

140
00:07:19,972 --> 00:07:21,774
The Thematic Mapper instrument,

141
00:07:21,774 --> 00:07:23,943
launched on Landsat 4 in 1982

142
00:07:23,943 --> 00:07:26,345
and on its twin Landsat 5 in ‘84,

143
00:07:26,345 --> 00:07:28,314
was a major step forward.

144
00:07:28,314 --> 00:07:30,283
Collecting seven different wavelengths,

145
00:07:30,283 --> 00:07:33,486
at better ground resolution, and with higher precision,

146
00:07:33,486 --> 00:07:35,655
this was the beating heart of the satellite

147
00:07:35,655 --> 00:07:39,692
and became the work horse for a generation of scientists.

148
00:07:39,692 --> 00:07:43,095
For the first time, Landsat data had three visible bands

149
00:07:43,095 --> 00:07:44,630
– red, green, and blue –

150
00:07:44,630 --> 00:07:48,100
allowing natural-color composite images.

151
00:07:48,100 --> 00:07:50,436
■■■

152
00:07:50,436 --> 00:07:53,239
And with the addition of short-wave infrared wavelengths,

153
00:07:53,239 --> 00:07:55,808
the data could better highlight flooded areas,

154
00:07:55,808 --> 00:08:00,246
mineral deposits, and burn scars from wildfires.

155
00:08:00,246 --> 00:08:02,081
■■■

156
00:08:02,081 --> 00:08:03,850
The thermal bands were also upgraded

157
00:08:03,850 --> 00:08:06,953
allowing individual farm fields to be tracked.

158
00:08:07,620 --> 00:08:09,455
■■■

159
00:08:09,455 --> 00:08:10,823
The sixth Landsat was intended

160
00:08:10,823 --> 00:08:12,859
to be another big step forward,

161
00:08:12,859 --> 00:08:16,262
but it never reached orbit after launch in 1993.

162
00:08:16,262 --> 00:08:18,531

Plans immediately began for Landsat 7,

163
00:08:18,531 --> 00:08:21,567
which would carry an even more improved sensor.

164
00:08:21,567 --> 00:08:24,003
At the time, the Enhanced Thematic Mapper Plus

165
00:08:24,003 --> 00:08:26,506
was the most stable Earth observation instrument

166
00:08:26,506 --> 00:08:28,941
ever sent into orbit, and the calibration

167
00:08:28,941 --> 00:08:31,577
could be updated while in space.

168
00:08:31,577 --> 00:08:32,578
For the first time,

169
00:08:32,578 --> 00:08:34,213
we had an instrument robust enough

170
00:08:34,213 --> 00:08:35,848
to collect lots of data,

171
00:08:35,848 --> 00:08:39,285
and we had a plan to thoroughly record the entire globe.

172
00:08:39,619 --> 00:08:42,889
Landsat 7 was put to work mapping coral reefs,

173
00:08:42,889 --> 00:08:44,156
and even produced the first

174
00:08:44,156 --> 00:08:45,992
high-resolution natural-color map

175
00:08:45,992 --> 00:08:48,094
of remote Antarctica.

176
00:08:49,362 --> 00:08:50,930
■■■

177
00:08:50,930 --> 00:08:53,499
Improvements to the thermal bands on Landsat 7

178
00:08:53,499 --> 00:08:54,767
allowed states and counties

179
00:08:54,767 --> 00:08:57,570
to gauge how much water was used by crops.

180
00:08:57,570 --> 00:09:01,107
This helps manage water resources efficiently.

181
00:09:01,507 --> 00:09:04,210
An important milestone occurred in 2008,

182
00:09:04,210 --> 00:09:07,747
when the USGS made the data available to download for free.

183
00:09:08,648 --> 00:09:11,150
Users were able to get the data they needed,

184
00:09:11,150 --> 00:09:13,119
and not just what they could afford.

185
00:09:13,119 --> 00:09:15,221
It really unlocked a ton of innovation

186
00:09:15,221 --> 00:09:17,356
and created about 2 billion dollars a year

187
00:09:17,356 --> 00:09:20,126

in economic benefits.

188
00:09:21,027 --> 00:09:22,161
■■■

189
00:09:22,161 --> 00:09:24,230
The modern era of Landsat observations

190
00:09:24,230 --> 00:09:27,199
began with the launch of Landsat 8 in 2013.

191
00:09:28,100 --> 00:09:30,503
Having a push-broom style sensor on Landsat 8

192
00:09:30,503 --> 00:09:34,073
was a big improvement over the older scanning sensor.

193
00:09:34,974 --> 00:09:37,276
The Landsat 8 ground system that USGS runs

194
00:09:37,443 --> 00:09:40,580
is capable of receiving a lot more data than before.

195
00:09:40,580 --> 00:09:43,983
We’re downloading over 725 scenes each day.

196
00:09:43,983 --> 00:09:47,386
That just wasn’t remotely possible until Landsat 8.

197
00:09:47,820 --> 00:09:50,056
The two European Sentinel-2 satellites

198
00:09:50,056 --> 00:09:51,991
were designed to mesh with Landsat

199
00:09:51,991 --> 00:09:54,493
so that users can treat data from all the satellites

200
00:09:54,493 --> 00:09:56,729
as if it came from one single source.

201
00:09:56,862 --> 00:09:59,498
Now we get observations every 2 or 3 days,

202
00:09:59,498 --> 00:10:01,167
instead of every 2 weeks.

203
00:10:01,167 --> 00:10:03,202
■■■

204
00:10:03,202 --> 00:10:07,807
2021 is the launch of Landsat 9, the next step forward.

205
00:10:08,207 --> 00:10:12,011
It will collect the best data ever recorded by a Landsat satellite,

206
00:10:12,011 --> 00:10:16,415
while still integrating seamlessly with the extensive archive.

207
00:10:17,049 --> 00:10:18,884
Since the early 1970s,

208
00:10:18,884 --> 00:10:23,089
Landsat satellites have allowed us to better manage our resources.

209
00:10:23,422 --> 00:10:26,025
Landsat data has enabled countless innovations

210
00:10:26,025 --> 00:10:29,829
and will let us track the effects of climate change into the future.

211
00:10:29,829 --> 00:10:32,198
■■■

212
00:10:32,198 --> 00:10:37,803

213
00:10:37,803 --> 00:10:38,771
■■■

214
00:10:38,771 --> 00:10:42,742
sigh

215
00:10:42,742 --> 00:10:46,746
This is it.

216
00:10:46,746 --> 00:10:50,750
I am standing at the place

217
00:10:50,750 --> 00:10:54,754
where the beryllium was mined for the James Webb Space Telescope.

218
00:11:02,762 --> 00:10:58,758
music

219
00:11:02,762 --> 00:11:06,766
Let’s take a step back. I travelled just south of Salt Lake City

220
00:11:06,766 --> 00:11:10,770
City to a town called Delta, Utah.

221
00:11:10,770 --> 00:11:14,774
Welp, here we are

222
00:11:14,774 --> 00:11:18,744
what is it, 5:30 in the morning. And then back on the road the next morning

223
00:11:18,744 --> 00:11:23,149
as the sun rose up to meet the beryllium miners all in my quest to find out…

224
00:11:24,550 --> 00:11:27,887
Where does beryllium come from?

225
00:11:27,887 --> 00:11:32,058
music

226
00:11:32,058 --> 00:11:34,760
So Utah is home to many valuable materials:

227
00:11:34,760 --> 00:11:38,764
copper, magnesium, uranium, gold and silver.

228
00:11:38,764 --> 00:11:42,768
But most of the world's beryllium is mined here. And engineers

229
00:11:42,768 --> 00:11:47,206
chose beryllium for Webb's mirrors because it is lightweight, it is strong

230
00:11:47,206 --> 00:11:50,743
and it is dimensionally stable. So that means

231
00:11:50,743 --> 00:11:55,347
means that it is not going to warp when operating at really cold temperatures.

232
00:11:55,347 --> 00:11:58,751
What is even here?

233
00:11:58,751 --> 00:12:02,755
As we drove down into the pit, learned that we were in fact

234
00:12:02,755 --> 00:12:06,759
fact driving on the beryllium. This rock looks

235
00:12:06,759 --> 00:12:08,661
nothing like metal.

236
00:12:08,661 --> 00:12:13,899
Where is the beryllium? How does this

237

00:12:13,899 --> 00:12:17,970
turn into this? I of course needed

238
00:12:17,970 --> 00:12:23,175
to speak to an expert, and he came in the form of the VP of operations – Greg Gregory.

239
00:12:23,175 --> 00:12:26,746
We are actually standing on the beryllium ore seam.

240
00:12:26,746 --> 00:12:30,750
Beryllium is in the volcanic ash dust.

241
00:12:30,750 --> 00:12:34,754
It was hydrothermally deposited millions of years ago

242
00:12:34,754 --> 00:12:38,758
and then coved by volcanic rock. We have to remove the volcanic rock

243
00:12:38,758 --> 00:12:42,762
on top of the ore seam and then use a scraper and a bulldozer

244
00:12:42,762 --> 00:12:46,766
to extract the ore that we're standing on top of.

245
00:12:53,906 --> 00:12:50,770
music

246
00:12:53,906 --> 00:12:59,745
90 percent of the beryllium that was mined in the world last year came from this deposit.

247
00:12:59,745 --> 00:13:02,748
Now let me clue you into how rare this

248
00:13:02,748 --> 00:13:06,752
this metal is. This area has most of the world's known beryllium,

249
00:13:06,752 --> 00:13:10,756
but the highest concentration runs through a 10-foot tall

250
00:13:10,756 --> 00:13:15,427
diagonal ribbon well below the surface of the ground.

251
00:13:16,929 --> 00:13:18,764
The ore concentration is

252
00:13:18,764 --> 00:13:22,768
0.25 percent beryllium.

253
00:13:22,768 --> 00:13:26,772
That means, in a ton of ore, there is about 5 pounds

254
00:13:26,772 --> 00:13:28,841
of beryllium.

255
00:13:29,341 --> 00:13:34,747
So to get to this point we had to remove 400 feet of rock

256
00:13:34,747 --> 00:13:38,751
to get to the ore seam. Once the ore is extracted, it goes

257
00:13:38,751 --> 00:13:42,755
through a bunch processing to extract the pure beryllium

258
00:13:42,755 --> 00:13:47,259
Then the powder beryllium is pressed into block ready for machining

259
00:13:47,827 --> 00:13:49,895
Webb's mirrors started out as solid

260
00:13:49,895 --> 00:13:55,000
5 foot tall, 5 foot wide and 2-inch-thick blocks of beryllium.

261
00:13:55,668 --> 00:13:58,270
But in order to machine those blocks

262

00:13:58,270 --> 00:14:01,307
millions of pounds of rock were removed.

263
00:14:01,307 --> 00:14:06,745
It comes to about 4 tons of rock for every pound of beryllium.

264
00:14:06,745 --> 00:14:09,448
That is a lot of work

265
00:14:09,448 --> 00:14:12,518
for one remarkable metal.

266
00:14:13,018 --> 00:14:14,286
■■■

267
00:14:14,286 --> 00:14:14,386
Don't record that. [laughing]

268
00:14:14,386 --> 00:14:19,225
"Behind the Scenes of Elements of Webb"
Ryan Fitzgibbons, Producer

269
00:14:19,692 --> 00:14:23,162
■■■

270
00:14:23,162 --> 00:14:24,930
I came up with Elements of Webb

271
00:14:24,930 --> 00:14:27,766
because I have seen in all of our articles
and videos

272
00:14:27,766 --> 00:14:30,135
that we kept mentioning that we used gold
and beryllium for these mirrors,

273
00:14:30,135 --> 00:14:32,371
gold and beryllium for these mirrors,

274
00:14:32,371 --> 00:14:34,807
that there are
all these special materials, but

275
00:14:34,807 --> 00:14:37,910
we didn't really explain why we used them.

276
00:14:37,910 --> 00:14:41,780
So I wanted to get sort of into the nitty
gritty of the material science

277
00:14:41,780 --> 00:14:45,351
to explore why these were
and then actually just demonstrate

278
00:14:45,351 --> 00:14:48,654
why these materials behave
the way they do.

279
00:14:48,654 --> 00:14:51,523
I got a piece! I got a piece!

280
00:14:51,690 --> 00:14:53,058
Not only was it a

281
00:14:53,058 --> 00:14:56,328
I think, cool science adventure for you
because you did a lot of research,

282
00:14:56,328 --> 00:14:59,565
It was an adventure
just going out and capturing everything.

283
00:14:59,565 --> 00:15:01,967
That's the great,
beautiful Salt Lake back there.

284
00:15:01,967 --> 00:15:02,668
Okay.

285
00:15:02,668 --> 00:15:05,704
We just got attacked by--they're still swarming around us--

286
00:15:05,704 --> 00:15:08,474
These little gnats.

287
00:15:08,941 --> 00:15:11,644
I will say that my proudest moment
was being able

288
00:15:11,644 --> 00:15:14,013
to go to the beryllium mine.

289
00:15:15,681 --> 00:15:18,117
That took a lot of work to get to.

290
00:15:18,117 --> 00:15:20,986
We found the beryllium shop,
and then we got them

291
00:15:20,986 --> 00:15:24,857
to talk to their people
and then convincing those people

292
00:15:24,857 --> 00:15:30,329
to let us fly into Salt Lake City and
actually go to the frickin beryllium mine.

293
00:15:30,329 --> 00:15:33,499
--This has all been mined out. So that's the--

294
00:15:33,499 --> 00:15:37,102
So we've had like so much latitude
in this project, which we're very lucky.

295
00:15:37,403 --> 00:15:40,873
But yeah,
so we were able to hire a drone operator,

296
00:15:40,873 --> 00:15:43,575
which was so cool.

297
00:15:45,711 --> 00:15:49,848
And so he was able to get perspectives
on this huge hole in the ground

298
00:15:49,848 --> 00:15:52,551
that we would never otherwise
be able to see

299
00:15:52,551 --> 00:15:58,457
and actually get like a really good
perspective on like just how massive it is

300
00:15:58,457 --> 00:16:03,295
and reall how much rock you have to remove to get
even the smallest amounts of beryllium.

301
00:16:04,330 --> 00:16:05,531
COVID

302
00:16:05,531 --> 00:16:08,267
just wiped this whole thing out
because we were planning to go

303
00:16:08,267 --> 00:16:11,403
to a lot of different places
and then when COVID hit and we couldn't

304
00:16:11,403 --> 00:16:14,473
go anywhere, she did,

305
00:16:14,473 --> 00:16:19,511
I want to say like 80%
of the whole production at your house.

306
00:16:19,511 --> 00:16:20,145

Yeah.

307
00:16:20,145 --> 00:16:23,048
And you did some amazing stuff
at your house.

308
00:16:23,048 --> 00:16:24,917
And we're recording.

309
00:16:24,917 --> 00:16:27,853
But first
I have to make some distilled water,

310
00:16:27,853 --> 00:16:30,422
but first
I have to make some distilled water.

311
00:16:30,556 --> 00:16:30,956
It was fun.

312
00:16:30,956 --> 00:16:35,794
I mean, it made me take a little more time
to think about what I was talking about.

313
00:16:35,794 --> 00:16:38,831
And I actually think
they ultimately made a better video.

314
00:16:38,831 --> 00:16:40,499
I already see two pieces.

315
00:16:40,499 --> 00:16:42,735
One of the great things about
this job is that, you know,

316
00:16:42,768 --> 00:16:44,870
we meet a lot of different people,
you learn a lot of stuff,

317

00:16:44,870 --> 00:16:48,774
but you're also able to go into places

318
00:16:48,774 --> 00:16:51,944
and see things that, you know,
nobody else gets to see.

319
00:16:51,944 --> 00:16:56,615
And I think the Element series
is really one of those projects

320
00:16:56,615 --> 00:17:00,719
that we were just able to go
and into different places.

321
00:17:01,120 --> 00:17:04,323
Sort of my philosophy on
life is just start doing the things

322
00:17:04,323 --> 00:17:05,357
that you want to do.

323
00:17:05,357 --> 00:17:08,027
You're never going to have the gear
that you want.

324
00:17:08,027 --> 00:17:10,696
You're never necessarily
going to have the time that you want.

325
00:17:10,696 --> 00:17:12,998
But like try to
figure it out and just, just

326
00:17:12,998 --> 00:17:15,934
just do it.

327
00:17:15,934 --> 00:17:19,138
■■■

328
00:17:19,138 --> 00:17:24,843
"Fermi Spots Fizzled Burst from Collapsing Star"
Scott Wiessinger, Producer; Chris Smith, Animator

329
00:17:24,843 --> 00:17:26,812
■■■

330
00:17:26,812 --> 00:17:29,348
NASA’s Fermi Gamma-ray Space Telescope

331
00:17:29,348 --> 00:17:33,352
has spotted the shortest burst of gamma rays ever seen from a collapsing

332
00:17:33,352 --> 00:17:37,356
star. It challenges the traditional classification of

333
00:17:37,356 --> 00:17:41,360
gamma-ray bursts, also called GRBs.

334
00:17:41,360 --> 00:17:45,364
Short GRBs – those lasting less than 2 seconds – are thought to

335
00:17:45,364 --> 00:17:49,368
occur when orbiting objects like neutron stars spiral together and

336
00:17:49,368 --> 00:17:53,372
merge. Longer bursts come from massive stars

337
00:17:53,372 --> 00:17:57,376
at the ends of their lives. A black hole forms at the center of the

338
00:17:57,376 --> 00:18:01,380
collapsing star. It drives long-lasting jets that drill through

339
00:18:01,380 --> 00:18:05,350
the star, producing gamma rays when they emerge.

340

00:18:05,350 --> 00:18:09,354
The star then transforms into a supernova.

341
00:18:09,354 --> 00:18:13,358
On August 26, 2020, Fermi detected a GRB lasting about

342
00:18:13,358 --> 00:18:17,362
1 second. Instruments on other spacecraft saw it

343
00:18:17,362 --> 00:18:21,366
too, including NASA's Wind and Mars Odyssey missions.

344
00:18:21,366 --> 00:18:25,370
They helped narrow down the location to a patch of sky in the constellation

345
00:18:25,370 --> 00:18:29,374
Andromeda. Less than a day after the GRB,

346
00:18:29,374 --> 00:18:33,378
astronomers identified a fading source of visible light using

347
00:18:33,378 --> 00:18:37,349
the Zwicky Transient Facility at Palomar Observatory.

348
00:18:37,349 --> 00:18:41,353
This was the burst's afterglow. NASA's Swift satellite

349
00:18:41,353 --> 00:18:45,357
soon recorded X-rays from it, and within days, ground-based radio telescopes

350
00:18:45,357 --> 00:18:47,726
observed it too.

351
00:18:47,726 --> 00:18:49,361
After a few weeks, when the

352
00:18:49,361 --> 00:18:53,365
afterglow had decayed, ground-based observatories confirmed the presence of

353
00:18:53,365 --> 00:18:57,369
a brightening supernova. This means the GRB must have come from

354
00:18:57,369 --> 00:19:01,373
a massive collapsing star, not a merger.

355
00:19:01,373 --> 00:19:05,844
Astronomers think this burst, called GRB 200826A,

356
00:19:05,844 --> 00:19:09,348
was on the verge of not occurring at all. About

357
00:19:09,348 --> 00:19:13,352
6.6 billion years ago, a massive star in a distant galaxy

358
00:19:13,352 --> 00:19:17,356
reached the end of its life. Its core collapsed and formed

359
00:19:17,356 --> 00:19:21,360
a black hole, which launched near-light-speed particle jets through

360
00:19:21,360 --> 00:19:25,364
the star. But just as they breached the surface, the jets

361
00:19:25,364 --> 00:19:29,368
shut down, producing a surprisingly brief GRB.

362
00:19:29,368 --> 00:19:33,372
Astronomers think it’s likely some short GRBs

363
00:19:33,372 --> 00:19:36,742
they’ve detected are misclassified as mergers when, instead

364
00:19:36,742 --> 00:19:40,879
they're really bursts from jets that nearly failed to drill through

365

00:19:40,879 --> 00:19:45,350
collapsing stars. We only detect GRBs when the jets

366
00:19:45,350 --> 00:19:49,354
aim in our direction. Even accounting for this, long

367
00:19:49,354 --> 00:19:53,358
GRBs still occur at a lower rate than the supernova type

368
00:19:53,358 --> 00:19:57,362
associated with them. This means most collapsing massive stars

369
00:19:57,362 --> 00:20:01,366
likely fail to produce long-lived jets

370
00:20:01,366 --> 00:20:05,370
– dying, at least from the gamma-ray perspective, with a

371
00:20:05,370 --> 00:20:08,040
whimper instead of a bang.

372
00:20:08,040 --> 00:20:11,543
■■■

373
00:20:11,543 --> 00:20:15,881
"Unboxing Apollo Samples"
James Tralie, Producer

374
00:20:15,881 --> 00:20:23,488
■■■

375
00:20:24,289 --> 00:20:25,090
Apollo 17, December 7, 1972 - December 9, 1972

376
00:20:25,090 --> 00:20:25,390
So we

377
00:20:25,390 --> 00:20:29,027

received samples from the Apollo
17 mission

378
00:20:29,027 --> 00:20:32,264
which were return to Earth
in December of 1972.

379
00:20:32,264 --> 00:20:33,799
So nearly 50 years ago.

380
00:20:34,466 --> 00:20:36,835
Basically we collected on the moon
and brought back,

381
00:20:37,336 --> 00:20:37,869
then they were

382
00:20:37,869 --> 00:20:40,405
frozen within about a month of being returned.

383
00:20:40,405 --> 00:20:42,641
So no one's ever looked at them since.

384
00:20:42,708 --> 00:20:44,610
It's very exciting.

385
00:20:44,610 --> 00:20:50,882
"Unboxing Apollo Samples"

386
00:20:51,683 --> 00:20:54,753
Curation facility at NASA's
Johnson Space Center

387
00:20:54,753 --> 00:20:58,590
sent us the samples and they did have to
do some special efforts to keep them cold

388
00:20:58,590 --> 00:21:00,492
because we wanted them to stay frozen.

389
00:21:00,492 --> 00:21:03,595
So they had a special cold shipping box
with panels

390
00:21:03,595 --> 00:21:06,698
that were frozen in a very cold freezer
and a chunk of dry ice.

391
00:21:07,699 --> 00:21:10,469
We picked it up from the receiving office
here at Goddard

392
00:21:11,837 --> 00:21:15,440
opened it up, pulled the samples out
and stuck them straight in our freezer

393
00:21:15,440 --> 00:21:16,708
and locked them up safely.

394
00:21:18,243 --> 00:21:19,144
So these

395
00:21:19,144 --> 00:21:21,847
frozen samples were actually collected
from a region on the Moon

396
00:21:21,847 --> 00:21:24,082
that was in shadow from the sun.

397
00:21:24,082 --> 00:21:26,251
So it was basically a large boulder.

398
00:21:26,251 --> 00:21:28,287
In the near future,
we're going back to the Moon

399
00:21:28,287 --> 00:21:30,022
and hopefully going to the polar

regions of the moon

400
00:21:30,022 --> 00:21:32,090
where some of these regions
are in permanent shadow

401
00:21:32,090 --> 00:21:34,960
and they don't see the sun, you know,
they're cold.

402
00:21:34,960 --> 00:21:39,131
These particular samples are really great
analogs for what we might expect

403
00:21:39,131 --> 00:21:41,566
to see in the polar regions
when we go back.

404
00:21:42,234 --> 00:21:45,170
So we actually started last week
to process the samples.

405
00:21:45,170 --> 00:21:49,908
So the samples we got are basically dirt,
lunar dirt, and we basically made "Moon

406
00:21:49,908 --> 00:21:50,776
tea" out of them.

407
00:21:50,776 --> 00:21:51,743
So "Moon tea"

408
00:21:51,743 --> 00:21:55,514
is what we call it when we pull out
the soluble compounds from the soil.

409
00:21:55,580 --> 00:21:59,251
And so we basically take the lunar sample,
seal it up with a torch in a little

410
00:21:59,251 --> 00:22:03,221
glass test tube full of water,
stick it in an oven overnight and boil it.

411
00:22:03,221 --> 00:22:06,258
And we're just pulling out
those soluble compounds that we care about

412
00:22:06,258 --> 00:22:08,960
the same way
you'd make tea with boiling water at home.

413
00:22:10,329 --> 00:22:12,364
What we're trying to do is answer some questions

414
00:22:12,364 --> 00:22:17,169
about the history this sample experienced
at the surface of the Moon.

415
00:22:17,169 --> 00:22:19,438
The surface of the Moon
is a really hostile environment.

416
00:22:19,438 --> 00:22:21,840
You know, it's not like here on Earth
where we have this

417
00:22:21,840 --> 00:22:26,812
beautiful atmosphere that protects us
from the nasties of space.

418
00:22:26,812 --> 00:22:30,215
So we have particles from the sun
that are continuously hitting the

419
00:22:30,215 --> 00:22:31,216
surface of the Moon.

420
00:22:31,216 --> 00:22:32,718

And we've got galactic

421
00:22:32,718 --> 00:22:36,388
cosmic rays that are coming in
and penetrating into the surface as well.

422
00:22:36,488 --> 00:22:40,492
They actually create noble gases
in these particles.

423
00:22:40,525 --> 00:22:42,861
So you can imagine that
there's none to begin with.

424
00:22:43,161 --> 00:22:46,498
And then as they get exposed
to this space environment,

425
00:22:46,765 --> 00:22:50,268
they kind of get more
and more buildup of noble gases.

426
00:22:50,669 --> 00:22:55,006
And our technique is to actually unlock
those noble gases from the sample,

427
00:22:55,173 --> 00:22:59,511
a measure of them, so we can come up with
what we call a cosmic ray exposure age.

428
00:22:59,878 --> 00:23:04,249
So it's basically how long this sample
has been sat at the surface being exposed.

429
00:23:04,416 --> 00:23:06,184
It's basically getting a "space tan."

430
00:23:07,552 --> 00:23:08,820
Say, 50 years ago,

431
00:23:08,820 --> 00:23:11,923
this same technique, which is called
the Noble Gas Mass Spectrometry

432
00:23:11,957 --> 00:23:16,428
would probably need anywhere,
you know, tens to hundreds of milligrams

433
00:23:16,428 --> 00:23:20,031
to do the same thing that we now
do with a couple of milligrams.

434
00:23:20,799 --> 00:23:23,402
It's really special
to be part of this, and particularly

435
00:23:23,402 --> 00:23:28,774
because I can look back at the papers
and the processes that the curation office

436
00:23:28,774 --> 00:23:32,511
and the scientists in the 1970s
thought about and they put so much care

437
00:23:32,511 --> 00:23:34,880
into preserving these samples
for future science

438
00:23:35,180 --> 00:23:37,382
to making sure
that they were going to be at their,

439
00:23:37,382 --> 00:23:40,152
you know, the best conditions
so that as we develop new techniques,

440
00:23:40,419 --> 00:23:43,855
we're able to go and look at these samples
and get new answers

441
00:23:44,122 --> 00:23:46,224
to the science questions
that were being asked.

442
00:23:46,224 --> 00:23:49,461
You know, I'm still studying these samples
50 years later

443
00:23:49,728 --> 00:23:52,364
for the from the Apollo mission,
the original Apollo missions

444
00:23:52,664 --> 00:23:55,734
and you know, you don't know
what's going to be in another 50 years,

445
00:23:55,734 --> 00:23:59,571
but I'm still a part of the Apollo dream
of going to the Moon

446
00:23:59,571 --> 00:24:00,939
and bringing samples back.

447
00:24:00,939 --> 00:24:04,409
So the fact that we have Artemis
now is amazing.

448
00:24:04,409 --> 00:24:07,078
Like having our own Artemis
generation is really exciting.

449
00:24:07,179 --> 00:24:11,383
I just can't wait to see
people go back to the Moon.

450
00:24:12,684 --> 00:24:14,986
■■■

451
00:24:14,986 --> 00:24:19,658

452
00:24:19,658 --> 00:24:20,559
There--

453
00:24:20,559 --> 00:24:20,892
Aww--

454
00:24:21,827 --> 00:24:24,563
There once was a star in a galaxy

455
00:24:24,563 --> 00:24:26,998
It was named the Sun and thankfully

456
00:24:26,998 --> 00:24:29,468
It weaves a solar tapestry

457
00:24:29,468 --> 00:24:32,537
Sends particles high and low

458
00:24:32,537 --> 00:24:35,273
Soon may the solar wind come

459
00:24:35,273 --> 00:24:37,876
To bring us plasma and magnetism

460
00:24:37,876 --> 00:24:40,312
Filled with hydrogen and helium

461
00:24:40,312 --> 00:24:43,014
And the solar wind will blow

462
00:24:43,014 --> 00:24:46,084
The solar wind charts a course

463
00:24:46,084 --> 00:24:48,987
Pulling lines of magnetic force

464
00:24:48,987 --> 00:24:50,989
Flowing outwards from the source

465
00:24:50,989 --> 00:24:53,492
Throws particles to and fro

466
00:24:53,492 --> 00:24:54,059
Hyuh!

467
00:24:54,059 --> 00:24:56,595
Soon may the solar wind come

468
00:24:56,595 --> 00:24:59,431
To bring us plasma and magnetism

469
00:24:59,431 --> 00:25:01,566
Filled with hydrogen and helium

470
00:25:01,566 --> 00:25:04,336
And the solar wind will blow

471
00:25:04,336 --> 00:25:07,405
The Earth spun with its iron core

472
00:25:07,405 --> 00:25:09,908
While the solar wind knocks at the door

473
00:25:09,908 --> 00:25:12,477
Magnetosphere screams “no more!”

474
00:25:12,477 --> 00:25:14,779
Until it must let go

475
00:25:14,779 --> 00:25:18,049
Once a magnetic line is freed

476

00:25:18,049 --> 00:25:20,485
Buckling under the wind’s stampede

477
00:25:20,485 --> 00:25:22,888
It whips back with tremendous speed

478
00:25:22,888 --> 00:25:25,957
Sends particles to the poles

479
00:25:25,957 --> 00:25:28,560
Soon may the solar wind come

480
00:25:28,560 --> 00:25:31,563
To bring us plasma and magnetism

481
00:25:31,563 --> 00:25:33,665
Filled with hydrogen and helium

482
00:25:33,665 --> 00:25:36,401
And the solar wind will blow

483
00:25:36,401 --> 00:25:38,904
The particles speed back here

484
00:25:38,904 --> 00:25:41,773
And ricochet through the atmosphere

485
00:25:41,773 --> 00:25:44,476
Exciting oxygen and nitrogen there

486
00:25:44,476 --> 00:25:47,345
Making those particles glow

487
00:25:47,345 --> 00:25:49,915
On and on the cycle spins

488
00:25:49,915 --> 00:25:52,584
Sun and Earth are celestial kin

489
00:25:52,584 --> 00:25:54,986
Dancing through the solar wind

490
00:25:54,986 --> 00:25:57,889
Connected by its flow

491
00:25:57,889 --> 00:26:00,458
Soon may the solar wind come

492
00:26:00,458 --> 00:26:03,361
To bring us plasma and magnetism

493
00:26:03,361 --> 00:26:05,463
Filled with hydrogen and helium

494
00:26:05,463 --> 00:26:08,633
And the solar wind will blow

495
00:26:08,633 --> 00:26:11,136
Soon may the solar wind come

496
00:26:11,136 --> 00:26:13,905
To bring us plasma and magnetism

497
00:26:13,905 --> 00:26:16,808
Filled with hydrogen and helium

498
00:26:16,808 --> 00:26:22,747
And the solar wind will blow

499
00:26:22,747 --> 00:26:23,815
■■■

500
00:26:23,815 --> 00:26:25,450
"An excerpt from Snack Time with NASA: Space Salad"
Katie Jepson, Katy Mersmann, Kathleen Gaeta, Producers

501
00:26:25,450 --> 00:26:27,652
Undressed bok choy.

502
00:26:27,652 --> 00:26:28,653
Woo. Ok.

503
00:26:28,653 --> 00:26:29,621
■■■

504
00:26:29,621 --> 00:26:31,957
Hey everyone, welcome to Snack Time with NASA.

505
00:26:31,990 --> 00:26:34,025
I'm your host, Kathleen Gaeta.

506
00:26:34,025 --> 00:26:36,595
Now, we've been exploring all the ways that NASA helps

507
00:26:36,595 --> 00:26:38,863
get some of your favorite foods onto your plate.

508
00:26:38,863 --> 00:26:42,400
And so far, all of those foods have been down here on Earth, obviously.

509
00:26:42,400 --> 00:26:44,102
But we're NASA, right?

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00:26:44,102 --> 00:26:48,506
So while we may not be professional chefs,
we do know a thing or two about space.

511
00:26:48,506 --> 00:26:51,443
That's why today we'll be learning
what it takes to grow food

512
00:26:51,476 --> 00:26:55,614
two hundred miles above our heads
onboard the International Space Station.

513
00:26:55,614 --> 00:26:56,581
And later, we'll hear

514
00:26:56,581 --> 00:27:00,685
how the space station helps us monitor
the health of plants down here on Earth.

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00:27:00,685 --> 00:27:02,020
So let's get into it.

516
00:27:02,020 --> 00:27:04,356
As you can see, I have a nice haul of greens right in front of me.

517
00:27:04,522 --> 00:27:08,593
Some romaine lettuce, some bok choy, radishes, micro greens.

518
00:27:08,593 --> 00:27:11,262
Now, I got all these ingredients from my local grocery store.

519
00:27:11,396 --> 00:27:15,066
But actually, every single one of these plants is grown onboard the ISS.

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00:27:15,066 --> 00:27:17,235
And here to help explain how that happens is

521
00:27:17,235 --> 00:27:18,837
Matt Romeyn, Project Scientist

522
00:27:18,837 --> 00:27:20,372
at the Kennedy Space Center.

523
00:27:20,372 --> 00:27:21,773
Matt, thank you so much for being here.

524
00:27:21,773 --> 00:27:25,310
How's it going?
Matt: Oh it's going good, glad to be here Kathleen.

525
00:27:25,443 --> 00:27:28,213
Kathleen: So you sent me a list of vegetables that you work with,

526
00:27:28,213 --> 00:27:30,382
and I'm wondering how you go about choosing

527
00:27:30,382 --> 00:27:32,584
which foods to grow up in space?

528
00:27:32,584 --> 00:27:37,422
Matt: We have to do a lot of crop screening. We're able to screen these crops and test them at our growth char

529
00:27:37,422 --> 00:27:40,091
at Kennedy Space Center that are able to replicate the environmental conditions

530
00:27:40,091 --> 00:27:43,328
on the International Space Station, except for microgravity.

531
00:27:45,263 --> 00:27:47,766
We're looking for how productive they grow, growth for compact

532
00:27:47,766 --> 00:27:51,803
morphologies and crops that are nutritious and flavorful.

533
00:27:51,803 --> 00:27:55,373
Kathleen: OK, I have to ask, have you ever grown potatoes in space?

534
00:27:56,374 --> 00:28:00,945
Matt: Well, we've been growing crops recently on ISS - last five years or so.

535
00:28:00,945 --> 00:28:03,882
We haven't had potatoes recently, but in the past we've done them

536
00:28:03,882 --> 00:28:04,983
on the shuttle program

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00:28:04,983 --> 00:28:07,786
and we have grown them extensively on the ground at Kennedy Space Center.

538
00:28:08,253 --> 00:28:12,157
Kathleen: I will eat a space potato in my lifetime, I promise you that.

539
00:28:12,157 --> 00:28:15,593
Anyways, so you suggested I pick up some bok choy and mustard

540
00:28:15,593 --> 00:28:19,330
greens, and I can't say those are typical salad ingredients for myself.

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00:28:19,330 --> 00:28:21,299
Matt: The bok choy is interesting because the crew recently

542
00:28:21,299 --> 00:28:24,869
grew and got to eat that on the ISS and they really enjoyed it.

543
00:28:25,103 --> 00:28:27,939
They actually found a way to cook it, using their food warmer

544
00:28:27,939 --> 00:28:32,077
and combining some garlic paste, soy sauce, and bit of olive oil.

545
00:28:32,544 --> 00:28:36,347
The mustard greens are great because they have a lot of strong flavors.

546
00:28:36,347 --> 00:28:39,384
And when you're an astronaut on the ISS, with the microgravity,

547
00:28:39,384 --> 00:28:41,286
you have a diminished sense of taste and smell.

548
00:28:41,286 --> 00:28:45,056
So they like those bolder flavors that kind of punch through there.

549
00:28:45,056 --> 00:28:46,725
Kathleen: Wow. I did not know that.

550
00:28:46,725 --> 00:28:51,629
And now, do you also grow the same plants
that you're growing in space down at KSC?

551
00:28:51,629 --> 00:28:55,133
Matt: Yeah, well, we're growing plants in space on ISS, we also have ground controls

552
00:28:55,133 --> 00:28:56,267
at KSC that

553
00:28:56,267 --> 00:28:59,904
replicate the exact conditions on the ISS - the temperature, humidity, the CO2

554
00:28:59,904 --> 00:29:04,876
levels, we can control for everything but the microgravity element.

555
00:29:04,909 --> 00:29:07,579
Kathleen: Ok, and I assume that so that you can more closely monitor

556
00:29:07,579 --> 00:29:10,749
the difference of plants growing in space versus on Earth.

557
00:29:10,749 --> 00:29:13,118
What have you discovered in that process?

558
00:29:13,118 --> 00:29:17,155
Matt: Well, we find that plants, for the most part,
grow similar in space as on Earth.

559
00:29:17,155 --> 00:29:19,324
A big variable is the water.

560
00:29:19,324 --> 00:29:23,361
There's a lack of convective
flow in space, and that makes water very

561
00:29:23,361 --> 00:29:26,965

sticky. Plants like a good mix of water
and oxygen in their root zone.

562
00:29:26,965 --> 00:29:30,201
And when we have water that doesn't mix well with

563
00:29:30,201 --> 00:29:33,705
oxygen, we get a lot of swinging back and forth between

564
00:29:33,705 --> 00:29:37,308
the roots being flooded and being in a state of drought.

565
00:29:37,308 --> 00:29:39,310
We have technologies that are working on that.

566
00:29:39,310 --> 00:29:41,346
To solve that problem of microgravity.

567
00:29:41,346 --> 00:29:45,884
Luckily, when we get to Mars and the moon,
those problems mostly go away.

568
00:29:45,884 --> 00:29:49,721
Kathleen: Got it. And so talk to me about this little space garden

569
00:29:49,721 --> 00:29:52,157
I keep hearing of - the VEGGIE Growth System. What is that?

570
00:29:52,157 --> 00:29:54,659
Yeah, the VEGGIE. We've got two of those on ISS,

571
00:29:54,659 --> 00:29:56,227
And it's a real simple system.

572
00:29:56,227 --> 00:29:59,697
It's about the size of a piece of carry-on luggage.

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00:29:59,697 --> 00:30:03,201

It uses LED lighting and has six little plant pillows in there

574
00:30:03,201 --> 00:30:07,672
that are filled with growth medium, which is basically a soil substitute.

575
00:30:07,672 --> 00:30:11,075
And that's how we're able to grow and propagate the plants on the ISS.

576
00:30:12,577 --> 00:30:13,912
Kathleen: That's so interesting.

577
00:30:13,912 --> 00:30:16,815
The vision of a space garden just brings a lot of joy to me

578
00:30:16,815 --> 00:30:18,216
and I'm sure a lot of people.

579
00:30:18,216 --> 00:30:20,919
Anyway, so is there a plant that you're kind of the most excited

580
00:30:20,919 --> 00:30:22,754
about trying to grow in space?

581
00:30:22,754 --> 00:30:23,955
Matt: Definitely peppers.

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00:30:23,955 --> 00:30:27,859
We actually just sent chili peppers to ISS,
that will be grown in the summer,

583
00:30:27,859 --> 00:30:31,362
and we're excited about peppers
because they are very challenging.

584
00:30:31,462 --> 00:30:33,531
They take a long time to germinate.

585
00:30:33,565 --> 00:30:36,634

They take a long time to grow, about 120 days.

586
00:30:37,035 --> 00:30:39,037
And there's a real challenge with the flavor.

587
00:30:39,070 --> 00:30:42,473
If we were to overwater them, they taste

588
00:30:42,473 --> 00:30:45,577
like grass clippings. If we under water,

589
00:30:45,577 --> 00:30:48,079
and we stress out a lot, they're really spicy.

590
00:30:48,079 --> 00:30:51,182
So we're trying to really control to grow healthy plants

591
00:30:51,182 --> 00:30:54,586
and flavorful plants that the crew wants to eat and enjoy.

592
00:30:54,853 --> 00:30:57,088
Kathleen: Right. And you know what they say,
if you can't take the heat,

593
00:30:57,088 --> 00:30:59,257
get off the space station, right? [polite laughter]

594
00:30:59,257 --> 00:31:02,026
Just kidding, that's my dad joke of the day!

595
00:31:02,060 --> 00:31:03,895
Well anyways, Matt I can't thank you enough for being here.

596
00:31:03,895 --> 00:31:05,730
[Bark] I learned a lot, and I hope you all did as well.

597
00:31:05,730 --> 00:31:09,400
And I can't wait to hear what you grow in space next!

Matt: Thank you.

598
00:31:09,400 --> 00:31:13,872
[Bark] Kathleen: Shut your little door, Buoy

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00:31:13,872 --> 00:31:15,607
■■■

600
00:31:15,607 --> 00:31:20,345
"Lucy's Journey Episode 4: Instruments"
James Tralie, Producer; Krystofer Kim, Animator

601
00:31:20,345 --> 00:31:25,183
■■■

602
00:31:25,183 --> 00:31:28,786
Nope, Lucy, still
a little way to go before

603
00:31:28,786 --> 00:31:31,389
you get to your first Trojan asteroid.

604
00:31:31,623 --> 00:31:36,861
But it looks like you're coming up to
the main belt asteroid, Donald Johanson.

605
00:31:37,028 --> 00:31:40,365
Right. This will give you a chance
to check in on your instrumentation

606
00:31:40,632 --> 00:31:42,700
before you get out to the Trojans.

607
00:31:42,700 --> 00:31:44,769
This first instrument is called L'Ralph.

608
00:31:45,103 --> 00:31:47,705
It will take color
images of the Trojan asteroids

609
00:31:47,872 --> 00:31:51,109
using visible and infrared light,
helping scientists

610
00:31:51,109 --> 00:31:55,380
map craters and mountains and figure out
what the asteroids are made out of.

611
00:31:55,780 --> 00:31:57,782
Next, this is L'LORRI.

612
00:31:57,782 --> 00:31:59,951
The long range reconnaissance imager.

613
00:32:00,518 --> 00:32:01,853
This camera will provide

614
00:32:01,853 --> 00:32:05,857
the most detailed images
of the surfaces of the Trojan asteroids.

615
00:32:05,857 --> 00:32:10,295
To help scientists figure out what's been
happening since our Solar System formed.

616
00:32:10,461 --> 00:32:13,798
This is L'TES, the thermal
emission spectrometer,

617
00:32:14,198 --> 00:32:16,200
basically a touchless thermometer.

618
00:32:16,200 --> 00:32:19,537
It will measure the temperatures
on the Trojan asteroids' surfaces

619
00:32:19,537 --> 00:32:22,941
to tell scientists

whether the surfaces are rocky or dusty.

620
00:32:23,541 --> 00:32:26,945
Lastly, you couldn't get the job done
without your tracking cameras

621
00:32:26,945 --> 00:32:31,349
or the T2CAMS to make sure
the asteroids are always in view

622
00:32:31,950 --> 00:32:35,119
and the high gain antenna
that lets you communicate with Earth.

623
00:32:35,286 --> 00:32:38,456
The scientists back at home
will use your radio signals

624
00:32:38,623 --> 00:32:42,460
to measure the mass of each
asteroid as you fly past it.

625
00:32:44,762 --> 00:32:45,830
Right, Lucy!

626
00:32:45,830 --> 00:32:46,698
How could I forget?

627
00:32:46,698 --> 00:32:49,934
You also have two huge solar panels

628
00:32:49,934 --> 00:32:53,271
to give you electrical power
as you fly out to the Trojan asteroids.

629
00:32:53,771 --> 00:32:57,775
Farther from the Sun
than any previous solar powered mission.

630

00:32:57,775 --> 00:33:01,713
Just a bit longer
now before you get to your first target.

631
00:33:01,713 --> 00:33:06,117
Rest up and get ready to put
all of those instruments to good use.

632
00:33:06,117 --> 00:33:10,621
I'll check back in with you once you
make it out to your first Trojan asteroid.

633
00:33:10,621 --> 00:33:13,758
■■■

634
00:33:13,758 --> 00:33:18,763
"An excerpt from What Is Your Favorite Hubble Image?"
Paul Morris, Producer

635
00:33:18,763 --> 00:33:19,731
■■■

636
00:33:19,731 --> 00:33:27,638
"We asked NASA scientists and astronauts...'What is your favorite Hubble image?'"

637
00:33:29,774 --> 00:33:38,850
Hi, my name is Paul Morris, and I'm a video\h
producer for the Hubble Space Telescope.

638
00:33:38,850 --> 00:33:43,888
Over the years, I've had the amazing opportunity\h
to interview some of the brightest minds in\h\h

639
00:33:43,888 --> 00:33:50,762
astrophysics, and some of the coolest astronauts\h
and people in the world. As a rule, I always ask\h\h

640
00:33:50,762 --> 00:33:55,733
every single person this one question. Every.\h
Single. Time.

641
00:33:55,733 --> 00:33:58,703
This is the cliche question,\h\h

642
00:33:58,703 --> 00:34:00,571
but what's your favorite Hubble image?\h
Oh, what is my favorite Hubble image? Ah.\h\h