1
00:00:00,666 --> 00:00:07,066
[music playing]

2
00:00:16,400 --> 00:00:18,700
[applause]

3
00:00:21,500 --> 00:00:25,100
- WELL, IT'S MY GREAT HONOR
TODAY TO INTRODUCE OUR SPEAKER.

4
00:00:25,100 --> 00:00:28,766
AND IT'S ALSO MY GREAT HONOR
TO INTRODUCE THIS

5
00:00:28,766 --> 00:00:33,300
AS ONE OF OUR KEY TALKS IN
THE 75th ANNIVERSARY CELEBRATION

6
00:00:33,300 --> 00:00:34,866
OF NASA AMES

7
00:00:34,866 --> 00:00:37,533
AND THE DIRECTOR'S
COLLOQUIUM SERIES.

8
00:00:37,533 --> 00:00:40,900
OUR SPEAKER TODAY
IS DR. ELLEN STOFAN.

9
00:00:40,900 --> 00:00:44,133
SHE WAS APPOINTED
THE NASA CHIEF SCIENTIST

10
00:00:44,133 --> 00:00:46,233
ON AUGUST 25th LAST YEAR.

11
00:00:46,233 --> 00:00:49,800
ALMOST A YEAR--TIME GOES QUICK
WHEN YOU'RE HAVING FUN, RIGHT?

12
00:00:49,800 --> 00:00:52,733
SHE SERVES AS
THE PRINCIPLE ADVISOR

13
00:00:52,733 --> 00:00:55,066
TO OUR ADMINISTRATOR,
CHARLIE BOLDEN

14
00:00:55,066 --> 00:00:56,800
ON THE AGENCY'S
SCIENCE PROGRAMS

15
00:00:56,800 --> 00:01:01,133
AND SCIENCE-RELATED STRATEGIC
PLANNING AND INVESTMENTS.

16
00:01:01,133 --> 00:01:03,866
SHE'S ALSO A MEMBER
OF THE AGENCY EXECUTIVE COUNCIL,

17
00:01:03,866 --> 00:01:06,966
SO SHE SPEAKS FOR US
COOL SCIENCE PEOPLE.

18
00:01:06,966 --> 00:01:10,200
SO, YOU KNOW, THE--
GIVE HER A GOOD WELCOME.

19
00:01:10,200 --> 00:01:11,866
SHE IS AN ASSOCIATE MEMBER

20
00:01:11,866 --> 00:01:15,000
OF THE CASSINI MISSION
TO SATURN RADAR TEAM,

21
00:01:15,000 --> 00:01:17,666
AND CO-INVESTIGATOR
IN THE MARS EXPRESS MISSIONS

22
00:01:17,666 --> 00:01:19,333
MARSIS SOUNDER.

23
00:01:19,333 --> 00:01:21,333
SHE WAS ALSO THE PRINCIPLE
INVESTIGATOR

24
00:01:21,333 --> 00:01:23,933
ON THE TITAN MARS EXPLORER,
A PROPOSED MISSION

25
00:01:23,933 --> 00:01:26,133
TO SEND A FLOATING LANDER
TO A SEA ON TITAN.

26
00:01:26,133 --> 00:01:27,900
THAT'S REALLY COOL.

27
00:01:27,900 --> 00:01:30,800
YOU KNOW, AND I'M AN AIR FORCE
GUY BUT, YOU KNOW,

28
00:01:30,800 --> 00:01:32,900
SOME OF THE NAVY PEOPLE SAID,
"WELL, THEY'RE NOT TALKING ABOUT

29
00:01:32,900 --> 00:01:34,433
FLYING AN AIRPLANE
IN THE ATMOSPHERE."

30
00:01:34,433 --> 00:01:36,466
I SAID, "WELL, WE DID,
BUT THEY DIDN'T GET PICKED."

31
00:01:36,466 --> 00:01:38,033
BUT SAILING A BOAT.

32
00:01:38,033 --> 00:01:40,100
SO WE HAVE A TITANIUM NAVY,

RIGHT?

33
00:01:42,866 --> 00:01:46,100
ELLEN HOLDS A MASTER
AND DOCTORATE DEGREE

34
00:01:46,100 --> 00:01:48,800
IN GEOLOGICAL SCIENCES
FROM BROWN UNIVERSITY

35
00:01:48,800 --> 00:01:50,366
IN PROVIDENCE, RHODE ISLAND,

36
00:01:50,366 --> 00:01:53,433
AND A BACHELOR'S DEGREE FROM
THE COLLEGE OF WILLIAM & MARY

37
00:01:53,433 --> 00:01:55,333
IN WILLIAMSBURG,
VIRGINIA.

38
00:01:55,333 --> 00:01:58,366
HER TALK TODAY IS ENTITLED
"NASA SCIENCE:

39
00:01:58,366 --> 00:02:01,066
LOOKING OUTWARD,
INWARD AND HOMEWARD."

40
00:02:01,066 --> 00:02:04,666
PLEASE JOIN ME IN WELCOMING
DR. ELLEN STOFAN.

41
00:02:04,666 --> 00:02:07,000
[applause]

42
00:02:12,033 --> 00:02:14,233
- GOOD AFTERNOON.

43

00:02:14,233 --> 00:02:16,166
I'M REALLY EXCITED
TO BE HERE,

44
00:02:16,166 --> 00:02:18,533
AND I'M EXCITED TO TALK
TO ALL OF YOU.

45
00:02:18,533 --> 00:02:20,633
BUT I UNDERSTAND THAT A LOT
OF YOU ARE SUMMER INTERNS

46
00:02:20,633 --> 00:02:22,066
HERE THIS SUMMER,

47
00:02:22,066 --> 00:02:24,400
AND SO I WAS WONDERING IF THE
INTERNS COULD RAISE THEIR HANDS

48
00:02:24,400 --> 00:02:26,066
SO I KNOW WHO YOU ARE.

49
00:02:26,066 --> 00:02:27,500
WOW. AWESOME.

50
00:02:27,500 --> 00:02:28,700
OH, PETE.

51
00:02:28,700 --> 00:02:30,133
[laughs]

52
00:02:30,133 --> 00:02:31,633
EXCELLENT.

53
00:02:31,633 --> 00:02:33,733
SO I'M HOPING
THAT MANY OF YOU

54
00:02:33,733 --> 00:02:35,900

COME BACK TO NASA
AT SOME POINT

55
00:02:35,900 --> 00:02:37,433
AND JOIN THIS AGENCY,

56
00:02:37,433 --> 00:02:39,633
BECAUSE WE'RE DOING
AMAZING THINGS.

57
00:02:39,633 --> 00:02:43,700
AND I HOPE TO GIVE YOU A LITTLE
SORT OF A BROAD BASE LOOK

58
00:02:43,700 --> 00:02:45,600
AT A LOT OF THE THINGS
WE DO.

59
00:02:45,600 --> 00:02:47,600
JUST FOCUSING ON A COUPLE
DIFFERENT AREAS

60
00:02:47,600 --> 00:02:50,100
THAT I'M PARTICULARLY WORKING ON
AT THE MOMENT,

61
00:02:50,100 --> 00:02:51,533
OR THINKING ABOUT.

62
00:02:51,533 --> 00:02:53,500
AND I LIKE TO TALK ABOUT--

63
00:02:53,500 --> 00:02:55,533
WHEN YOU THINK
OF NASA SCIENCE,

64
00:02:55,533 --> 00:02:57,233
YOU KNOW, OFTEN OUT
IN THE GENERAL PUBLIC,

65
00:02:57,233 --> 00:02:59,333
THERE'S--WE WERE TALKING ABOUT
THIS EARLIER.

66
00:02:59,333 --> 00:03:01,733
THERE'S CONFUSION THAT NASA
ACTUALLY STILL EXISTS.

67
00:03:01,733 --> 00:03:05,200
BUT MOVING BEYOND THAT,
SOME PEOPLE ARE MOSTLY FAMILIAR

68
00:03:05,200 --> 00:03:06,433
WITH OUR LOOKING OUTWARD.

69
00:03:06,433 --> 00:03:07,966
YOU KNOW, OUR STUDIES
OF THE PLANETS,

70
00:03:07,966 --> 00:03:09,400
OUR STUDIES
OF THE UNIVERSE.

71
00:03:09,400 --> 00:03:10,833
ALL THE GREAT SCIENCE
THAT WE DO

72
00:03:10,833 --> 00:03:13,633
THAT OFTEN MAKES IT ONTO THE
FRONT PAGES OF THE NEWSPAPER.

73
00:03:13,633 --> 00:03:15,833
WHAT THEY'RE A LITTLE LESS
FAMILIAR WITH,

74
00:03:15,833 --> 00:03:18,433
AND WHICH THERE'S CERTAINLY
A LOT OF EXPERTISE HERE AT AMES,

75

00:03:18,433 --> 00:03:20,233
IS THE LOOKING INWARD
THAT WE DO,

76
00:03:20,233 --> 00:03:23,633
UNDERSTANDING THE EFFECTS OF
MICROGRAVITY ON LIVING SYSTEMS

77
00:03:23,633 --> 00:03:25,500
THAT WE ARE REALLY
FOCUSED ON

78
00:03:25,500 --> 00:03:27,400
ON THE INTERNATIONAL
SPACE STATION.

79
00:03:27,400 --> 00:03:29,533
AND THEN THERE'S
THE LOOKING HOMEWARD,

80
00:03:29,533 --> 00:03:31,400
AND I'M GOING TO SPEND
A LITTLE BIT OF TIME

81
00:03:31,400 --> 00:03:32,766
TALKING ABOUT THAT
THIS AFTERNOON.

82
00:03:32,766 --> 00:03:36,200
WE HAVE 18 SATELLITES IN ORBIT
AROUND THE EARTH

83
00:03:36,200 --> 00:03:40,200
DOING EARTH SCIENCE EVERY DAY,
MAKING CRITICAL MEASUREMENTS

84
00:03:40,200 --> 00:03:42,466
TO HELP US UNDERSTAND
OUR OWN PLANET.

85

00:03:42,466 --> 00:03:45,966
AND THIS, TO ME,
SORT OF SUMMARIZES

86
00:03:45,966 --> 00:03:48,666
ALL OF THE SCIENCE
THAT WE DO AT NASA,

87
00:03:48,666 --> 00:03:51,533
FROM TRYING TO UNDERSTAND
THE BEHAVIOR OF OUR OWN STAR--

88
00:03:51,533 --> 00:03:55,066
THE SUN--TO OUR LOOKING BACK
INTO THE EARLIEST MOMENTS

89
00:03:55,066 --> 00:03:56,900
OF THE UNIVERSE,

90
00:03:56,900 --> 00:03:59,500
TRYING TO UNDERSTAND THE NATURE
OF STAR FORMATION,

91
00:03:59,500 --> 00:04:01,933
UNIVERSE FORMATION,
GALAXY FORMATION,

92
00:04:01,933 --> 00:04:03,700
TO THE RESEARCH
THAT WE'RE DOING

93
00:04:03,700 --> 00:04:05,833
UP ON THE INTERNATIONAL
SPACE STATION

94
00:04:05,833 --> 00:04:09,633
TO HELP US PREPARE TO SEND
HUMANS BEYOND LOW EARTH ORBIT

95
00:04:09,633 --> 00:04:12,900

FROM THE INVESTIGATIONS THAT WE
DO HERE ON OUR OWN SOLAR SYSTEM.

96
00:04:12,900 --> 00:04:14,533
WE OBVIOUSLY HAVE
SPACECRAFT RIGHT NOW

97
00:04:14,533 --> 00:04:16,433
PRETTY MUCH SPANNING
THE SOLAR SYSTEM,

98
00:04:16,433 --> 00:04:18,866
FROM THE MESSENGER MISSION
AT MERCURY

99
00:04:18,866 --> 00:04:21,366
TO THE "NEW HORIZONS"
SPACECRAFT, WHICH NOW,

100
00:04:21,366 --> 00:04:24,300
A FEW DAYS SHORT
OF ONE YEAR FROM NOW,

101
00:04:24,300 --> 00:04:26,900
"NEW HORIZONS" WILL HAVE ITS
CLOSEST ENCOUNTER WITH PLUTO,

102
00:04:26,900 --> 00:04:29,633
WHICH IS GOING TO BE
INCREDIBLY EXCITING

103
00:04:29,633 --> 00:04:31,100
TO GET A CLOSE LOOK AT PLUTO.

104
00:04:31,100 --> 00:04:35,066
AND, YES, I KNOW PLUTO
IS NOT TECHNICALLY A PLANET.

105
00:04:35,066 --> 00:04:36,366
[man speaks indistinctly]

106
00:04:36,366 --> 00:04:37,933
[laughs]
IT WAS WHEN WE LAUNCHED.

107
00:04:37,933 --> 00:04:39,966
THAT'S RIGHT.
THINGS CHANGE.

108
00:04:39,966 --> 00:04:41,933
BUT NEVERTHELESS...

109
00:04:41,933 --> 00:04:44,133
AND, OF COURSE,
AS THIS IMAGE INDICATES,

110
00:04:44,133 --> 00:04:47,133
THE NEW--THE JUNO MISSION,

111
00:04:47,133 --> 00:04:49,033
WHICH IS GOING TO BE STUDYING
JUPITER SOON.

112
00:04:49,033 --> 00:04:51,733
SO REALLY, SPACECRAFT
ALL ACROSS THE SOLAR SYSTEM.

113
00:04:51,733 --> 00:04:54,133
ALMOST EVERY DAY YOU CAN GO
ONTO OUR NASA WEBSITES

114
00:04:54,133 --> 00:04:57,366
AND FIND SOME COOL
SOLAR SYSTEM SCIENCE

115
00:04:57,366 --> 00:05:00,400
THAT'S BEEN RETURNED.

116
00:05:00,400 --> 00:05:01,900

AND FINALLY, AGAIN,
THE WORK THAT WE DO

117
00:05:01,900 --> 00:05:03,333
OBSERVING OUR OWN PLANET,

118
00:05:03,333 --> 00:05:06,766
JUST ABOUT IN EVERY WAVELENGTH
OF THE ELECTROMAGNETIC SPECTRUM,

119
00:05:06,766 --> 00:05:09,300
FROM REGIONS LIKE
OUR FRAGILE COASTLINES

120
00:05:09,300 --> 00:05:12,433
TO OBSERVATIONS OF THE OCEAN,
THE EARTH'S ATMOSPHERE.

121
00:05:12,433 --> 00:05:15,933
BUT WHEN YOU LOOK AT NASA,
THIS IS PRETTY MUCH

122
00:05:15,933 --> 00:05:17,900
HOW WE'RE ORGANIZED,
IN THESE DIFFERENT DIVISIONS.

123
00:05:17,900 --> 00:05:19,800
AND AS CHIEF SCIENTIST,
I HAVE THE FUN JOB

124
00:05:19,800 --> 00:05:23,666
OF BEING ABLE TO LOOK ACROSS
ALL OF THIS SCIENCE THAT WE DO.

125
00:05:23,666 --> 00:05:25,633
AND ONE OF THE THINGS
I LIKE TO DO

126
00:05:25,633 --> 00:05:27,766
IS TRY TO COMMUNICATE

THE CONNECTIONS,

127
00:05:27,766 --> 00:05:29,233
BECAUSE THERE ARE HUGE
CONNECTIONS

128
00:05:29,233 --> 00:05:31,933
BETWEEN ALL OF THESE DIFFERENT
AREAS OF SCIENCE WE PURSUE.

129
00:05:31,933 --> 00:05:35,400
WE REALLY--WE MIGHT BE ORGANIZED
INTO THESE STOVEPIPES,

130
00:05:35,400 --> 00:05:38,766
BUT WE ACTUALLY--A LOT OF US
DON'T OPERATE THAT WAY.

131
00:05:38,766 --> 00:05:41,933
AND IF YOU THINK ABOUT
THE FUNDAMENTAL QUESTIONS

132
00:05:41,933 --> 00:05:44,266
THAT DRIVE WHAT WE DO,
AND YOU CAN FIND THESE QUESTIONS

133
00:05:44,266 --> 00:05:46,200
IN ALL OF OUR
DRIVING DOCUMENTS,

134
00:05:46,200 --> 00:05:49,633
THE DECADAL SURVEYS THAT
THE NATIONAL RESEARCH COUNCIL

135
00:05:49,633 --> 00:05:51,233
HELPS THE COMMUNITY
PUT TOGETHER

136
00:05:51,233 --> 00:05:54,000
WHAT ARE SORT OF THE TOP

QUESTIONS IN SCIENCE.

137
00:05:54,000 --> 00:05:56,300
AND THOSE FUNDAMENTAL
QUESTIONS

138
00:05:56,300 --> 00:05:58,900
ARE HOW NASA DEVELOPS
ITS SCIENCE POLICY,

139
00:05:58,900 --> 00:06:00,633
HOW WE DECIDE
WHAT TO DO NEXT.

140
00:06:00,633 --> 00:06:02,233
WE REALLY LOOK OUT
TO THE COMMUNITY

141
00:06:02,233 --> 00:06:03,833
THROUGH THOSE DECADAL SURVEYS.

142
00:06:03,833 --> 00:06:06,566
THEN WE DEVELOP OUR OWN
STRATEGIC PLANS.

143
00:06:06,566 --> 00:06:09,233
AND REALLY,
IN THOSE DOCUMENTS

144
00:06:09,233 --> 00:06:11,400
YOU'LL FIND BASICALLY
THESE THREE QUESTIONS

145
00:06:11,400 --> 00:06:13,766
WHICH ARE GETTING AT
HOW DOES EVERYTHING FORM,

146
00:06:13,766 --> 00:06:17,366
WHAT'S THE ORIGIN OF STARS,
OF PLANETS OF THE UNIVERSE,

147
00:06:17,366 --> 00:06:20,000
AND THEN HOW DO THEY CHANGE
OVER TIME?

148
00:06:20,000 --> 00:06:22,366
AND SO TODAY I WANTED
TO TALK ABOUT--

149
00:06:22,366 --> 00:06:23,833
START TALKING--

150
00:06:23,833 --> 00:06:26,400
START OUT TALKING ABOUT
THAT BOTTOM QUESTION.

151
00:06:26,400 --> 00:06:28,866
HOW DOES OUR UNIVERSE WORK?

152
00:06:28,866 --> 00:06:31,766
BECAUSE AS A PLANET,
WE REALLY WANT TO KNOW

153
00:06:31,766 --> 00:06:33,566
HOW DOES THIS--

154
00:06:33,566 --> 00:06:37,200
OUR LOCAL SOLAR SYSTEM
ENVIRONMENT EVOLVE OVER TIME?

155
00:06:37,200 --> 00:06:38,866
HOW HAS THAT
AFFECTED THE EARTH,

156
00:06:38,866 --> 00:06:41,866
BOTH IN THE PAST
AND MOVING INTO THE FUTURE?

157
00:06:41,866 --> 00:06:46,000

AND CERTAINLY ONE OF THE
FUNDAMENTAL ISSUES WITH THAT

158
00:06:46,000 --> 00:06:48,466
IS WHAT'S GOING ON
ON OUR SUN.

159
00:06:48,466 --> 00:06:52,366
WE GET THESE HUGE ERUPTIONS
IN CORONAL MASS EJECTIONS,

160
00:06:52,366 --> 00:06:54,100
SOLAR FLARES OF PARTICLES

161
00:06:54,100 --> 00:06:55,900
THAT COME STREAMING
TOWARDS THE EARTH.

162
00:06:55,900 --> 00:06:57,633
AS THOSE PARTICLES GO BY--

163
00:06:57,633 --> 00:06:59,533
FOR EXAMPLE, VENUS.

164
00:06:59,533 --> 00:07:01,700
VENUS DOES NOT HAVE
A MAGNETIC FIELD.

165
00:07:01,700 --> 00:07:04,133
SO THOSE--THOSE--
THAT SOLAR WIND,

166
00:07:04,133 --> 00:07:06,200
THOSE STRIPPING OF PARTICLES
ACTUALLY STRIP AWAY

167
00:07:06,200 --> 00:07:08,633
THE TOP LAYERS OF THE ATMOSPHERE
OF VENUS,

168
00:07:08,633 --> 00:07:10,566
CONTRIBUTING TO THE FACT
THAT VENUS NOW HAS

169
00:07:10,566 --> 00:07:13,400
THIS INCREDIBLY INHOSPITABLE
CLIMATE.

170
00:07:13,400 --> 00:07:15,333
BUT WHEN THEY REACHED
THE EARTH,

171
00:07:15,333 --> 00:07:19,200
THOSE WERE PROTECTED
BY OUR MAGNETIC FIELD.

172
00:07:19,200 --> 00:07:21,600
AND SO THOSE WONDERFUL
MAGNETIC FIELD LINES

173
00:07:21,600 --> 00:07:23,466
SEND ALL THOSE PARTICLES
AROUND THE EARTH,

174
00:07:23,466 --> 00:07:26,066
PROTECTING US FROM
SOLAR PARTICLE--

175
00:07:26,066 --> 00:07:28,000
PROTECTING US
FROM COSMIC RAYS

176
00:07:28,000 --> 00:07:30,000
HERE ON THE SURFACE
OF THE EARTH.

177
00:07:30,000 --> 00:07:32,866
BUT OBVIOUSLY, IF WE WANT
TO SEND ASTRONAUTS

178
00:07:32,866 --> 00:07:35,633
OUT BEYOND OUR LITTLE
PALE BLUE DOT

179
00:07:35,633 --> 00:07:37,266
INTO DEEP SPACE,

180
00:07:37,266 --> 00:07:39,266
WE HAVE TO LEARN
HOW TO PROTECT THEM

181
00:07:39,266 --> 00:07:41,266
FROM THAT HARSH
SOLAR ENVIRONMENT.

182
00:07:41,266 --> 00:07:43,900
AND, AGAIN, THAT'S SOME OF
THE RESEARCH THAT WE'RE DOING

183
00:07:43,900 --> 00:07:45,300
RIGHT HERE AT AMES

184
00:07:45,300 --> 00:07:48,566
BUT ALSO UP ON THE INTERNATIONAL
SPACE STATION EVERY DAY.

185
00:07:48,566 --> 00:07:50,233
SO IF YOU REALLY THINK
OF THE EARTH

186
00:07:50,233 --> 00:07:55,033
AS BEING THIS FAIRLY FRAGILE,
LITTLE PALE BLUE DOT IN SPACE

187
00:07:55,033 --> 00:08:00,100
THAT CAN BE HUGELY AFFECTED
BY THINGS LIKE SOLAR STORMS,

188
00:08:00,100 --> 00:08:02,766

YOU CAN THEN TURN
TO WHAT'S GOING ON

189
00:08:02,766 --> 00:08:04,333
ON OUR PLANET RIGHT NOW.

190
00:08:04,333 --> 00:08:05,733
AND THESE ARE THE DEVIATIONS

191
00:08:05,733 --> 00:08:07,166
FROM AVERAGE
SURFACE TEMPERATURES

192
00:08:07,166 --> 00:08:10,566
STARTING IN THE 1890s AND GOING
ALL THE WAY TO THE PRESENT.

193
00:08:10,566 --> 00:08:14,333
SO FROM NATURAL EFFECTS
LIKE A SOLAR STORM

194
00:08:14,333 --> 00:08:17,966
TO MAN-MADE EFFECTS,
OR CLIMATE CHANGE.

195
00:08:17,966 --> 00:08:21,333
AND AS YOU SEE, ESPECIALLY
MOVING INTO THE 1990s,

196
00:08:21,333 --> 00:08:22,966
INTO THE EARLY 2000s,

197
00:08:22,966 --> 00:08:26,666
WHEN YOU SEE THAT TEMPERATURE
JUST GOING UP AND UP AND UP

198
00:08:26,666 --> 00:08:30,933
WITH PARTICULARLY STRONG EFFECTS
IN SUB-SAHARAN AFRICA,

199
00:08:30,933 --> 00:08:33,833
WHERE YOU HAVE POPULATIONS
THAT ARE REALLY THE LEAST ABLE

200
00:08:33,833 --> 00:08:36,700
TO ADAPT TO ANY KIND
OF CLIMATE CHANGE,

201
00:08:36,700 --> 00:08:39,400
TO HUGE CHANGES GOING ON
IN THE ARCTIC.

202
00:08:39,400 --> 00:08:41,500
AND AGAIN, AS YOU SEE THIS CYCLE
BACK AROUND,

203
00:08:41,500 --> 00:08:45,533
YOU'LL SEE GOING FROM ABOUT
THE LATE '90s TO THE PRESENT

204
00:08:45,533 --> 00:08:47,833
THE TEMPERATURE JUST GOING
UP AND UP AND UP

205
00:08:47,833 --> 00:08:50,400
IN THE ARCTIC REGION.

206
00:08:50,400 --> 00:08:53,800
HUGE IMPACT ON THE POPULATIONS
THAT LIVE THERE,

207
00:08:53,800 --> 00:08:56,366
AND REALLY
A SORT OF A BELLWETHER

208
00:08:56,366 --> 00:08:59,300
FOR WHAT IS GOING TO HAPPEN
TO THE REST OF THE PLANET.

209

00:08:59,300 --> 00:09:01,566
AND OBVIOUSLY THIS IS HAVING
HUGE EFFECTS.

210
00:09:01,566 --> 00:09:03,700
THAT CONCENTRATION OF HIGHER
AVERAGE SURFACE TEMPERATURES

211
00:09:03,700 --> 00:09:06,133
UP IN THE ARCTIC IS HAVING
A PRACTICAL EFFECT.

212
00:09:06,133 --> 00:09:08,866
IT'S MELTING THE POLAR ICE CAPS
OVER TIME

213
00:09:08,866 --> 00:09:11,833
SO THAT EVERY SUMMER,
MORE OR LESS,

214
00:09:11,833 --> 00:09:14,933
WE HAVE LESS AND LESS SURFACE
AREA IN THE ARCTIC OCEAN

215
00:09:14,933 --> 00:09:16,200
COVERED BY SEA ICE.

216
00:09:16,200 --> 00:09:18,733
THE SEA ICE THAT REMAINS
TENDS TO BE THINNER.

217
00:09:18,733 --> 00:09:20,133
IT TENDS TO OFTEN BE DARKER,

218
00:09:20,133 --> 00:09:24,333
SO THAT THAT POLAR ARCTIC REGION
ABSORBS MORE AND MORE HEAT.

219
00:09:24,333 --> 00:09:26,333
THAT IS THEN GIVEN OFF.

220
00:09:26,333 --> 00:09:29,966
IT'S DUMPING ENERGY INTO OUR
CLIMATE AND WEATHER SYSTEM.

221
00:09:29,966 --> 00:09:32,400
AND WHAT'S THE EFFECT OF THAT?

222
00:09:32,400 --> 00:09:34,533
TO BE HONEST WITH YOU,
WE DON'T KNOW.

223
00:09:34,533 --> 00:09:38,533
JUST THIS PAST YEAR
THROUGH THE NATIONAL ACADEMY,

224
00:09:38,533 --> 00:09:40,166
OR THE NATIONAL RESEARCH
COUNCIL,

225
00:09:40,166 --> 00:09:42,433
THERE WAS A BIG MEETING
OF SCIENTISTS GETTING TOGETHER

226
00:09:42,433 --> 00:09:45,400
AND DEBATING, YOU KNOW,
WHAT IS THE EFFECT

227
00:09:45,400 --> 00:09:48,266
OF THIS INCREASED HEAT PULSE
INTO THE ARCTIC REGION?

228
00:09:48,266 --> 00:09:49,866
IS IT CAUSING
SOME OF THE WEIRD WEATHER

229
00:09:49,866 --> 00:09:52,900
WE HAD ON THE EAST COAST,
FOR EXAMPLE, THIS PAST WINTER?

230
00:09:52,900 --> 00:09:55,100
WE DON'T KNOW YET.
IT'S JUST--IT'S TOO SOON.

231
00:09:55,100 --> 00:09:56,866
WE DON'T HAVE ENOUGH DATA.

232
00:09:56,866 --> 00:10:00,066
BUT THE FACT THAT THE ARCTIC
IS CHANGING SO MUCH

233
00:10:00,066 --> 00:10:02,966
SO RAPIDLY TO THE POINT, AGAIN,
BY THE 2030s

234
00:10:02,966 --> 00:10:04,800
WE THINK THERE'LL BE
VERY LITTLE ICE COVER

235
00:10:04,800 --> 00:10:06,666
IN THE SUMMER
IN THE ARCTIC,

236
00:10:06,666 --> 00:10:10,300
IT'S CLEARLY HAVING
LONG-TERM IMPLICATIONS,

237
00:10:10,300 --> 00:10:13,033
AGAIN, NOT JUST ON THE PEOPLE
WHO LIVE IN THE ARCTIC,

238
00:10:13,033 --> 00:10:15,300
BUT ON THE REST OF US.

239
00:10:15,300 --> 00:10:19,666
AND SO IT'S FRUSTRATING
FOR MANY OF US WHEN YOU SAY,

240
00:10:19,666 --> 00:10:22,533

"WELL, WHEN CLIMATE CHANGE
OCCURS IN THE FUTURE."

241
00:10:22,533 --> 00:10:23,866
AND YOU SAY,
"OKAY, FOR THE PEOPLE

242
00:10:23,866 --> 00:10:25,366
"WHO ARE LIVING
IN THE ARCTIC.

243
00:10:25,366 --> 00:10:27,833
IT'S SOMETHING WE OBSERVE
EVERY DAY."

244
00:10:27,833 --> 00:10:31,133
NOW IF YOU SAY,
"OKAY, HOW CAN NASA

245
00:10:31,133 --> 00:10:33,366
ACTUALLY PLAY
A ROLE IN THIS?"

246
00:10:33,366 --> 00:10:37,766
AND CLEARLY, AGAIN,
WE HAVE THOSE 18 SATELLITES,

247
00:10:37,766 --> 00:10:40,100
NOT TO MENTION THE AIRCRAFT
PROGRAM THAT WE DO.

248
00:10:40,100 --> 00:10:42,066
WE HAVE THOSE 18 SATELLITES,
YOU KNOW,

249
00:10:42,066 --> 00:10:44,133
AND ALL DIFFERENT INSTRUMENTS.

250
00:10:44,133 --> 00:10:46,366
EVERY PHASE OF THE

ELECTROMAGNETIC SPECTRUM

251
00:10:46,366 --> 00:10:49,366
WHERE WE'RE OBSERVING
AT DIFFERENT TIMES OF THE DAY,

252
00:10:49,366 --> 00:10:53,400
AT DIFFERENT INTERVALS,
ATMOSPHERIC CHEMISTRY,

253
00:10:53,400 --> 00:10:56,766
CLOUD COVER,
SURFACE LAND CHANGE,

254
00:10:56,766 --> 00:10:59,833
SURFACE WINDS,
UPPER ATMOSPHERIC WINDS--

255
00:10:59,833 --> 00:11:01,100
A WHOLE RANGE
OF MEASUREMENTS

256
00:11:01,100 --> 00:11:03,866
TO GET AT EACH OF THESE
DIFFERENT ASPECTS.

257
00:11:03,866 --> 00:11:06,166
WE HAVE THIS INCREDIBLY
COMPLEX PLANET.

258
00:11:06,166 --> 00:11:09,066
I ALWAYS TELL PEOPLE THAT'S WHY
I'D RATHER STUDY VENUS OR TITAN,

259
00:11:09,066 --> 00:11:11,400
BECAUSE YOU DON'T HAVE
ALL THIS PESKY VEGETATION

260
00:11:11,400 --> 00:11:14,900
AND, YOU KNOW,

PEOPLE AND STUFF AROUND.

261
00:11:14,900 --> 00:11:16,166
SO THEY'RE MUCH SIMPLER.

262
00:11:16,166 --> 00:11:18,266
SO IF YOU'RE TRYING
TO UNDERSTAND A PLANET

263
00:11:18,266 --> 00:11:20,033
AS COMPLEX AS THE EARTH,

264
00:11:20,033 --> 00:11:22,166
YOU NEED AN AWFUL LOT
OF DATA TO DO THAT.

265
00:11:22,166 --> 00:11:24,766
AND OBVIOUSLY YOU'RE ALSO
DOING GREAT THINGS HERE AT AMES

266
00:11:24,766 --> 00:11:26,166
THROUGH THE NEXT PROGRAM.

267
00:11:26,166 --> 00:11:28,500
I'M TRYING TO MAKE THAT DATA
MORE EASILY AVAILABLE

268
00:11:28,500 --> 00:11:31,033
AND USABLE
TO THE BROAD COMMUNITY.

269
00:11:31,033 --> 00:11:35,500
AND SO THIS YEAR IS A YEAR
THAT WE'RE, IN PARTICULAR,

270
00:11:35,500 --> 00:11:37,566
REALLY EXCITED ABOUT.

271
00:11:37,566 --> 00:11:38,933

FOR THE FIRST TIME
IN OVER A DECADE,

272
00:11:38,933 --> 00:11:42,333
WE HAVE FIVE "MISSION TO PLANET
EARTH" MISSIONS

273
00:11:42,333 --> 00:11:43,866
BEING LAUNCHED THIS YEAR.

274
00:11:43,866 --> 00:11:47,233
THE GOOD NEWS IS TWO OF THEM
HAVE ALREADY LAUNCHED,

275
00:11:47,233 --> 00:11:49,033
SO WE HAVE THREE MORE
TO WAIT FOR.

276
00:11:49,033 --> 00:11:53,100
GPM, THE GLOBAL PRECIPITATION
MEASUREMENT CORE,

277
00:11:53,100 --> 00:11:55,566
WAS LAUNCHED IN FEBRUARY.

278
00:11:55,566 --> 00:11:58,166
OCO-2 WAS JUST LAUNCHED
AT THE BEGINNING OF THIS MONTH,

279
00:11:58,166 --> 00:12:01,766
AND BOTH SATELLITES
ARE DOING REALLY WELL.

280
00:12:01,766 --> 00:12:04,466
WHAT I LOVE
ABOUT THE MISSIONS,

281
00:12:04,466 --> 00:12:07,100
ESPECIALLY THAT WE'RE LAUNCHING
THIS YEAR,

282
00:12:07,100 --> 00:12:10,600
IS YOU CAN REALLY ILLUSTRATE
HOW NASA'S TRYING TO ATTACK

283
00:12:10,600 --> 00:12:14,300
THESE FUNDAMENTAL PROBLEMS
IN SUCH A COMPREHENSIVE WAY.

284
00:12:14,300 --> 00:12:17,433
TAKE GPM AND SMAP.

285
00:12:17,433 --> 00:12:20,800
AND ON THAT PREVIOUS SLIDE,
YOU SAW THE WATER CYCLE.

286
00:12:20,800 --> 00:12:22,033
WELL, YOU CAN THINK OF WATER

287
00:12:22,033 --> 00:12:23,966
AS SORT OF BEING
A PROXY FOR ENERGY,

288
00:12:23,966 --> 00:12:25,766
AND THAT'S OBVIOUSLY
REALLY CRITICAL

289
00:12:25,766 --> 00:12:27,833
TO THE WORKINGS
OF THE CLIMATE SYSTEM.

290
00:12:27,833 --> 00:12:32,366
WITH GPM, WE'RE MEASURING
GLOBAL PRECIPITATION

291
00:12:32,366 --> 00:12:34,833
AROUND THE GLOBE
EVERY THREE HOURS,

292

00:12:34,833 --> 00:12:36,933
AND WE'RE NOT JUST MEASURING
HOW MUCH DID IT RAIN.

293
00:12:36,933 --> 00:12:39,900
WE'RE MEASURING WHAT WAS
THE SIZE OF THE RAINDROPS?

294
00:12:39,900 --> 00:12:41,600
WAS THERE ICE MIXED IN?

295
00:12:41,600 --> 00:12:43,766
A FAVORITE OF OURS
ON THE EAST COAST:

296
00:12:43,766 --> 00:12:45,300
MIXED PRECIPITATION.

297
00:12:45,300 --> 00:12:47,633
AND THE SIZES
OF THOSE ICE DROPLETS.

298
00:12:47,633 --> 00:12:50,166
WAS IT SNOWING?
SLEETING?

299
00:12:50,166 --> 00:12:52,933
AND EXACTLY WHAT KIND
OF PRECIPITATION IS GOING ON?

300
00:12:52,933 --> 00:12:56,433
AND, AGAIN, THAT'S IMPORTANT
FOR ONE THING,

301
00:12:56,433 --> 00:12:58,700
BECAUSE, AGAIN,
WATER CAN BE THOUGHT OF

302
00:12:58,700 --> 00:13:01,800
AS A PROXY FOR ENERGY

IN THE CLIMATE CYCLE,

303
00:13:01,800 --> 00:13:03,666
BUT ALSO BECAUSE
GO BACK TO THE FACT

304
00:13:03,666 --> 00:13:08,233
THAT OVER 70% OF THE EARTH'S
SURFACE IS COVERED BY WATER.

305
00:13:08,233 --> 00:13:10,033
NOBODY'S OUT THERE
WITH RAIN GAUGES

306
00:13:10,033 --> 00:13:11,333
MEASURING HOW MUCH
IT RAINS

307
00:13:11,333 --> 00:13:14,100
OR KNOWING WHAT TYPE
OF PRECIPITATION IS FALLING.

308
00:13:14,100 --> 00:13:17,033
SO SPACE-BASED MEASUREMENTS
IS THE ONLY WAY

309
00:13:17,033 --> 00:13:21,433
WE CAN GET A COMPREHENSIVE LOOK
AT THAT INPUT

310
00:13:21,433 --> 00:13:23,833
INTO THE WATER CYCLE.

311
00:13:23,833 --> 00:13:27,100
NOW SMAP IS TAKING
A DIFFERENT LOOK AT IT.

312
00:13:27,100 --> 00:13:29,400
SMAP IS MEASURING
SOIL MOISTURE.

313
00:13:29,400 --> 00:13:31,400
SO, OKAY, AGAIN,
THINK OF THE WATER CYCLE,

314
00:13:31,400 --> 00:13:33,733
PRECIPITATION,
EVAPORATION.

315
00:13:33,733 --> 00:13:35,533
THERE'S SOMETHING ELSE
IN THERE.

316
00:13:35,533 --> 00:13:38,233
I'M NOT GOOD AT THAT SONG
MY KIDS CAN SING.

317
00:13:38,233 --> 00:13:42,700
SMAP IS GOING TO BE MEASURING
LAND SURFACE SOIL MOISTURE--

318
00:13:42,700 --> 00:13:46,400
AGAIN, CRITICAL TO UNDERSTANDING
THE WATER CYCLE,

319
00:13:46,400 --> 00:13:48,733
BUT ALSO CRITICAL
ON A FUNDAMENTAL SCALE

320
00:13:48,733 --> 00:13:50,266
TO FARMERS WHO WANT TO KNOW

321
00:13:50,266 --> 00:13:53,500
HOW MUCH WATER
THEIR SOIL IS RETAINING.

322
00:13:53,500 --> 00:13:55,366
WHERE ARE THE WET AREAS,
WHERE'S THE DRY,

323
00:13:55,366 --> 00:13:58,766
WHAT ARE THE TRENDS, HOW CAN WE
INPUT THAT DATA INTO MODELS?

324
00:13:58,766 --> 00:14:00,600
NOW A SATELLITE
THAT WE'VE ALREADY LAUNCHED

325
00:14:00,600 --> 00:14:02,633
THAT'S NOT ON THIS,
GRACE,

326
00:14:02,633 --> 00:14:05,766
IS TAKING ANOTHER PART
OF THAT WATER CYCLE ISSUE.

327
00:14:05,766 --> 00:14:08,700
GRACE MEASURES CHANGES
IN THE EARTH'S SURFACE,

328
00:14:08,700 --> 00:14:09,966
GETS AT GRAVITY.

329
00:14:09,966 --> 00:14:12,700
BUT WE CAN ALSO ACTUALLY USE IT
TO LOOK AT AQUIFERS.

330
00:14:12,700 --> 00:14:16,566
WHEN AQUIFERS HAVE BEEN GOING
IN GENERAL DOWN THESE DAYS--

331
00:14:16,566 --> 00:14:17,866
FOR EXAMPLE, IN INDIA,

332
00:14:17,866 --> 00:14:19,633
WE'VE SEEN IT HERE
IN CALIFORNIA--

333
00:14:19,633 --> 00:14:22,433

WE'VE ACTUALLY BEEN ABLE
TO MEASURE VERY PRECISELY

334
00:14:22,433 --> 00:14:23,800
WHEN THE EARTH'S SURFACE
GOES DOWN

335
00:14:23,800 --> 00:14:25,900
BECAUSE WE'VE BEEN
DRAINING AQUIFERS,

336
00:14:25,900 --> 00:14:28,500
IN A LOT OF CASES
IRREVERSIBLY.

337
00:14:28,500 --> 00:14:30,666
THEY'RE NOT FILLING
BACK UP AGAIN.

338
00:14:30,666 --> 00:14:33,433
AND SO WE CAN ACTUALLY GO
INTO THE THIRD DIMENSION,

339
00:14:33,433 --> 00:14:35,333
DOWN INTO THE SURFACE
OF THE EARTH,

340
00:14:35,333 --> 00:14:38,666
AND UNDERSTAND MORE ABOUT THE
WATER BALANCE ON THE PLANET.

341
00:14:38,666 --> 00:14:39,966
SO WITH THREE NASA SATELLITES,

342
00:14:39,966 --> 00:14:42,066
WE'RE ACTUALLY ATTACKING
ALL DIFFERENT PIECES

343
00:14:42,066 --> 00:14:43,800
OF THIS WATER CYCLE.

344
00:14:43,800 --> 00:14:45,900
SO NOT JUST A PIECE
OF INFORMATION HERE OR THERE,

345
00:14:45,900 --> 00:14:47,900
BUT A WHOLE SERIES OF PIECES
OF INFORMATION

346
00:14:47,900 --> 00:14:51,233
THAT WE CAN KNIT TOGETHER
TO BETTER UNDERSTAND

347
00:14:51,233 --> 00:14:53,066
SOME OF THESE VERY
FUNDAMENTAL CYCLES

348
00:14:53,066 --> 00:14:55,900
ON OUR EXTREMELY
COMPLEX PLANET.

349
00:14:55,900 --> 00:14:59,966
AND THE OTHER THING I WILL SAY
THAT'S EXCITING ABOUT THIS YEAR

350
00:14:59,966 --> 00:15:02,266
IS THAT TWO
OF THESE INSTRUMENTS:

351
00:15:02,266 --> 00:15:04,800
RAPIDSCAT AND CAT,

352
00:15:04,800 --> 00:15:06,800
THE CLOUD-AEROSOL
TRANSPORT SYSTEM,

353
00:15:06,800 --> 00:15:08,200
ARE BOTH GOING TO BE MOUNTED

354

00:15:08,200 --> 00:15:09,766
ON THE INTERNATIONAL
SPACE STATION.

355
00:15:09,766 --> 00:15:12,500
SO BEING ABLE TO UTILIZE
THIS AMAZING PLATFORM

356
00:15:12,500 --> 00:15:16,266
THAT WE HAVE IN SPACE TO BE
DOING EARTH SCIENCE OBSERVATIONS

357
00:15:16,266 --> 00:15:18,933
IN A DIFFERENT ORBIT
THAN A LOT OF THE POLAR ORBITS

358
00:15:18,933 --> 00:15:20,833
THAT WE PUT SATELLITES INTO,

359
00:15:20,833 --> 00:15:23,166
IT'S VERY COMPLEMENTARY TO A LOT
OF THE OTHER DATA SETS

360
00:15:23,166 --> 00:15:24,566
THAT WE'RE COLLECTING,

361
00:15:24,566 --> 00:15:27,033
SO WE'RE REALLY EXCITED
ABOUT THAT ALSO.

362
00:15:28,633 --> 00:15:30,866
NOW, IF WE'RE TRYING TO
UNDERSTAND THIS COMPLEX PLANET,

363
00:15:30,866 --> 00:15:34,333
AGAIN, IT REALLY HELPS
TO PUT IT INTO CONTEXT.

364
00:15:34,333 --> 00:15:36,533
AND FOR A LOT OF YOU

SUMMER INTERNS,

365
00:15:36,533 --> 00:15:38,400
A LOT OF THE TIMES WHEN
I'M TELLING PEOPLE, YOU KNOW,

366
00:15:38,400 --> 00:15:39,800
FOR A LONG TIME
PEOPLE WILL SAY,

367
00:15:39,800 --> 00:15:42,100
"WHY DO YOU STUDY THOSE OTHER
PLANETS ANYWAY?"

368
00:15:42,100 --> 00:15:46,966
AND I TRY TO USE THE ANALOGY OF
JUST THINK IF YOU WERE A DOCTOR

369
00:15:46,966 --> 00:15:49,400
AND YOU ONLY HAD ONE PATIENT.

370
00:15:49,400 --> 00:15:52,033
YOU MIGHT REALLY START
TO UNDERSTAND THAT PATIENT,

371
00:15:52,033 --> 00:15:54,600
LIKE WHEN THEY MIGHT GET SICK,
WHEN THEY MIGHT GET BETTER,

372
00:15:54,600 --> 00:15:56,333
HOW RESILIENT THEY ARE
TO DISEASE.

373
00:15:56,333 --> 00:16:00,100
BUT YOU'D NEVER BE ABLE TO
UNDERSTAND THE NATURE OF DISEASE

374
00:16:00,100 --> 00:16:03,033
UNLESS YOU HAD LOTS AND LOTS
OF PATIENTS.

375
00:16:03,033 --> 00:16:05,066
AND I WOULD ARGUE,
AS A GEOLOGIST,

376
00:16:05,066 --> 00:16:08,300
WE HAVE THAT SAME ISSUE IF WE
ONLY HAVE THE EARTH TO STUDY.

377
00:16:08,300 --> 00:16:11,600
I PRIMARILY STUDY VOLCANOES
ON PLANETARY SURFACES.

378
00:16:11,600 --> 00:16:14,533
AND SO IF I CAN HAVE MULTIPLE
BODIES TO STUDY

379
00:16:14,533 --> 00:16:16,566
THAT HAVE SLIGHTLY DIFFERENT
TEMPERATURE AND PRESSURE--

380
00:16:16,566 --> 00:16:18,166
SLIGHTLY DIFFERENT ROCK
COMPOSITIONS,

381
00:16:18,166 --> 00:16:21,633
MAYBE SOMETIMES THE ROCKS
ARE MORE WET, MORE DRY,

382
00:16:21,633 --> 00:16:23,133
DIFFERENT ATMOSPHERIC PRESSURE,

383
00:16:23,133 --> 00:16:24,366
DIFFERENT ATMOSPHERIC
TEMPERATURE,

384
00:16:24,366 --> 00:16:25,700
DIFFERENT GRAVITY--

385

00:16:25,700 --> 00:16:27,300
I CAN START KNITTING
ALL THOSE DIFFERENT

386
00:16:27,300 --> 00:16:29,300
PHYSICAL SITUATIONS TOGETHER

387
00:16:29,300 --> 00:16:32,566
AND START TO BETTER UNDERSTAND
HOW A PHYSICAL PROCESS--

388
00:16:32,566 --> 00:16:36,166
THE ERUPTION OF A VOLCANO--
HOW THAT OPERATES.

389
00:16:36,166 --> 00:16:39,500
SO BY HAVING NOT JUST THE EARTH
BUT VENUS, MARS,

390
00:16:39,500 --> 00:16:41,933
THE ICY SATELLITES
IN THE SOLAR SYSTEM,

391
00:16:41,933 --> 00:16:43,800
I CAN DO COMPARATIVE
PLANETOLOGY

392
00:16:43,800 --> 00:16:45,533
AND I CAN START
UNDERSTANDING

393
00:16:45,533 --> 00:16:49,400
HOW PLANETARY PROCESSES
BETTER WORK.

394
00:16:49,400 --> 00:16:52,066
AND OBVIOUSLY ONE OF THE THINGS
WE REALLY LIKE TO DO

395
00:16:52,066 --> 00:16:55,366

IN OUR PROGRESSION
OF HOW WE STUDY PLANETS

396
00:16:55,366 --> 00:16:59,766
IS GO FROM ORBITERS
THAT COLLECT REMOTE DATA...

397
00:16:59,766 --> 00:17:01,533
WELL, WE USUALLY START
WITH FLY-BYS

398
00:17:01,533 --> 00:17:04,500
WHEN WE CAN'T
GET INTO ORBIT.

399
00:17:04,500 --> 00:17:07,733
AND THEN WE ORBIT AND COLLECT
GLOBAL COMPREHENSIVE DATA SETS.

400
00:17:07,733 --> 00:17:11,466
AND ONCE WE HAVE A GOOD IDEA
OF THE GLOBAL NATURE OF A BODY,

401
00:17:11,466 --> 00:17:13,000
WE LIKE TO GET DOWN
ON THE SURFACE.

402
00:17:13,000 --> 00:17:15,500
WHETHER IT'S GETTING DOWN
ON THE SURFACE OF AN ASTEROID,

403
00:17:15,500 --> 00:17:19,633
THE MOON, VENUS, AS THE SOVIETS
DID BACK IN THE 1980s,

404
00:17:19,633 --> 00:17:22,500
MARS, WHICH I'LL TALK A LOT
ABOUT IN A MINUTE.

405
00:17:22,500 --> 00:17:25,666

ONE OF MY FAVORITE PLACES
IN THE SOLAR SYSTEM: TITAN,

406
00:17:25,666 --> 00:17:28,300
WITH THOSE LITTLE WHITE,
ROUND PEBBLES.

407
00:17:28,300 --> 00:17:30,633
AND THEN, OF COURSE,
WE HAVE THESE BODIES

408
00:17:30,633 --> 00:17:33,533
TO ACTUALLY COMPARE
BACK TO THE EARTH.

409
00:17:33,533 --> 00:17:36,400
SO WHEN WE HAVE THAT IN SITU,
THAT SURFACE DATA,

410
00:17:36,400 --> 00:17:39,466
WE CAN START REALLY LOOKING
AT GEOLOGIC PROCESSES,

411
00:17:39,466 --> 00:17:42,366
LIKE HOW DO LAVA FLOWS FORM?

412
00:17:42,366 --> 00:17:44,066
WE CAN LOOK AT THOSE
VERY SMOOTH,

413
00:17:44,066 --> 00:17:45,466
PLATY LAVA FLOWS ON VENUS

414
00:17:45,466 --> 00:17:47,933
AND START TO BETTER UNDERSTAND
HOW THEY COMPARE

415
00:17:47,933 --> 00:17:50,466
TO VOLCANIC ERUPTIONS
HERE ON EARTH.

416
00:17:50,466 --> 00:17:52,966
WE CAN LOOK AT THOSE LITTLE
ROUNDED PEBBLES

417
00:17:52,966 --> 00:17:54,666
ON THE SURFACE OF TITAN

418
00:17:54,666 --> 00:17:58,000
AND KNOW THAT TO GET A LITTLE
ROUNDED ROCK LIKE THAT,

419
00:17:58,000 --> 00:18:01,066
IT HAS TO BE TUMBLED
BY A STREAM, TUMBLED IN A RIVER.

420
00:18:01,066 --> 00:18:02,700
AND INDEED, THAT IS
WHAT HAPPENED TO IT.

421
00:18:02,700 --> 00:18:05,400
BUT, OF COURSE,
THOSE RIVERS AND STREAMS

422
00:18:05,400 --> 00:18:08,666
HAVE LIQUID METHANE AND ETHANE
FLOWING IN THEM, NOT WATER,

423
00:18:08,666 --> 00:18:10,100
BECAUSE ON TITAN,

424
00:18:10,100 --> 00:18:12,933
IT'S 94 DEGREES KELVIN
ON THE SURFACE--

425
00:18:12,933 --> 00:18:16,066
REALLY, REALLY, REALLY,
REALLY COLD.

426

00:18:16,066 --> 00:18:18,333
SO WATER IS NOT STABLE
AS A LIQUID,

427
00:18:18,333 --> 00:18:20,266
BUT LIQUID METHANE IS.

428
00:18:20,266 --> 00:18:22,700
BUT ALL OF A SUDDEN WE HAVE
THESE SAME PROCESSES

429
00:18:22,700 --> 00:18:25,000
THAT OCCUR
HERE ON THE EARTH,

430
00:18:25,000 --> 00:18:29,766
RIVERS, STREAMS, LAKES, SEAS,

431
00:18:29,766 --> 00:18:31,633
AND ALL THE PROCESSES
THAT COME WITH THAT--

432
00:18:31,633 --> 00:18:33,866
WAVES, CURRENTS, TIDES.

433
00:18:33,866 --> 00:18:37,733
BUT NOW IT'S ON A BODY
WITH A DIFFERENT WORKING FLUID,

434
00:18:37,733 --> 00:18:41,300
DIFFERENT GRAVITY.
WHOLE DIFFERENT WORLD.

435
00:18:41,300 --> 00:18:43,300
SOMETHING TO COMPARE
THE EARTH TO

436
00:18:43,300 --> 00:18:46,900
TO BETTER UNDERSTAND,
FOR EXAMPLE, MARINE PROCESSES.

437
00:18:46,900 --> 00:18:49,300
EXTREMELY EXCITING.

438
00:18:49,300 --> 00:18:53,533
SO IT'S SOMETHING WE'D LIKE TO
ULTIMATELY SOMEDAY INVESTIGATE

439
00:18:53,533 --> 00:18:55,600
A LITTLE MORE CLOSELY.

440
00:18:57,500 --> 00:18:59,833
NOW, THE TOP QUESTION
ON THAT SLIDE--

441
00:18:59,833 --> 00:19:01,900
I'VE BEEN MOSTLY
TALKING ABOUT...

442
00:19:01,900 --> 00:19:06,066
ABOUT HOW
THE SOLAR SYSTEM WORKS.

443
00:19:06,066 --> 00:19:08,666
AND THE TOP QUESTION

444
00:19:08,666 --> 00:19:11,400
ON THAT LIST WAS,
"ARE WE ALONE?"

445
00:19:11,400 --> 00:19:14,766
AND IF YOU GO OUT
TO THE GENERAL PUBLIC

446
00:19:14,766 --> 00:19:16,133
AND START TALKING TO THEM

447
00:19:16,133 --> 00:19:18,266
ABOUT THE SCIENCE

THAT WE DO AT NASA,

448
00:19:18,266 --> 00:19:20,266
THAT'S PROBABLY THE QUESTION

449
00:19:20,266 --> 00:19:23,200
THAT I GET ASKED
MOST FREQUENTLY.

450
00:19:23,200 --> 00:19:24,766
MOST FREQUENTLY IT'S,
YOU KNOW,

451
00:19:24,766 --> 00:19:26,633
"DO YOU THINK THERE'S LIFE
ON EUROPA OR MARS?"

452
00:19:26,633 --> 00:19:28,966
AND THEN IT'S, "WOULD NASA TELL
PEOPLE IF WE FOUND IT?"

453
00:19:28,966 --> 00:19:31,266
YES, OF COURSE WE WOULD
TELL PEOPLE IF WE FOUND IT.

454
00:19:31,266 --> 00:19:34,966
BUT THIS QUESTION
OF "ARE WE ALONE"

455
00:19:34,966 --> 00:19:38,233
I THINK IS ONE THAT RESONATES
WITH EVERYBODY,

456
00:19:38,233 --> 00:19:41,266
BECAUSE IT'S SUCH A FUNDAMENTAL
QUESTION THAT YOU HAVE,

457
00:19:41,266 --> 00:19:42,533
THAT HUMANS HAVE HAD FOREVER

458
00:19:42,533 --> 00:19:44,166
WHEN YOU LOOK UP
INTO THE NIGHT SKY

459
00:19:44,166 --> 00:19:47,133
AND SAY, "ARE WE THE ONLY THINGS
OUT THERE?"

460
00:19:47,133 --> 00:19:50,300
WELL, OBVIOUSLY APPROACHING THAT
FROM A SCIENTIFIC POINT OF VIEW,

461
00:19:50,300 --> 00:19:54,266
YOU SAY, "WELL, WHAT WERE THE
INGREDIENTS HERE ON THE EARTH

462
00:19:54,266 --> 00:19:56,433
THAT LED TO THE FORMATION
OF LIFE?"

463
00:19:56,433 --> 00:19:58,400
AND THOSE INGREDIENTS
THAT WE'VE COME UP WITH

464
00:19:58,400 --> 00:20:00,866
ARE A SOURCE OF ENERGY
AND NUTRIENTS.

465
00:20:00,866 --> 00:20:02,633
THAT'S PRETTY EASY
IN OUR SOLAR SYSTEM

466
00:20:02,633 --> 00:20:04,400
WITH VOLCANOES, LIGHTNING,

467
00:20:04,400 --> 00:20:07,400
LOTS OF SOURCES OF ENERGY,
SOURCES OF NUTRIENTS.

468

00:20:07,400 --> 00:20:10,400
CARBON--ADVANCED CARBON
COMPOUNDS--

469
00:20:10,400 --> 00:20:13,966
AGAIN, NOT VERY HARD--
OCCUR IN LOTS OF PLACES.

470
00:20:13,966 --> 00:20:16,600
I WAS HEARING TODAY
OUT IN THE INTERSTELLAR MEDIUM,

471
00:20:16,600 --> 00:20:17,833
COMETS, ASTEROIDS.

472
00:20:17,833 --> 00:20:19,700
EVERYWHERE WE GO,
WE FIND CARBON COMPOUNDS.

473
00:20:19,700 --> 00:20:21,733
SO THAT'S NOT THE TOUGH PART.

474
00:20:21,733 --> 00:20:24,066
THE TOUGH PART TURNS OUT
TO BE LIQUID WATER,

475
00:20:24,066 --> 00:20:26,433
WHICH WE THINK IS CRITICAL
FOR THE FORMATION OF LIFE.

476
00:20:26,433 --> 00:20:28,100
AND LIQUID WATER--

477
00:20:28,100 --> 00:20:29,966
WATER'S OBVIOUSLY ONLY STABLE
AS A LIQUID

478
00:20:29,966 --> 00:20:32,500
IN A FAIRY LIMITED
TEMPERATURE BOUND.

479
00:20:32,500 --> 00:20:35,800
SO WHERE COULD WE GO
IN OUR SOLAR SYSTEM

480
00:20:35,800 --> 00:20:37,266
TO FIND THOSE CONDITIONS?

481
00:20:37,266 --> 00:20:40,666
I WOULD ARGUE THERE'S ALSO A
FOURTH CONDITION TO THOSE THREE,

482
00:20:40,666 --> 00:20:42,833
AND THAT'S STABILITY
OF ENVIRONMENT.

483
00:20:42,833 --> 00:20:45,666
THAT IF THE CONDITIONS
ARE CHANGING ALL THE TIME,

484
00:20:45,666 --> 00:20:47,866
IT'S GOING TO BE REALLY HARD
TO ALLOW THE CHEMISTRY

485
00:20:47,866 --> 00:20:51,100
TO GO FORWARD TO GET VERY MUCH
LIFE TO OCCUR.

486
00:20:51,100 --> 00:20:52,900
SO MAYBE IT'S GOING TO BE
REALLY HARD TO FIND.

487
00:20:52,900 --> 00:20:55,233
SO THE LONGER
THOSE CONDITIONS

488
00:20:55,233 --> 00:20:59,166
WHERE LIQUID WATER IS STABLE,
FOR EXAMPLE, PERSIST--

489
00:20:59,166 --> 00:21:01,100
A STABLE RADIATION
ENVIRONMENT,

490
00:21:01,100 --> 00:21:02,266
A MORE OR LESS STABLE

491
00:21:02,266 --> 00:21:03,800
TEMPERATURE AND PRESSURE
ENVIRONMENT--

492
00:21:03,800 --> 00:21:05,900
THE MORE LIKELY YOU ARE
TO GET LIFE.

493
00:21:05,900 --> 00:21:09,766
WELL, IN THE CENTER
OF THAT SLIDE IS OBVIOUSLY

494
00:21:09,766 --> 00:21:13,400
ONE OF THE CHIEF AREAS THAT
WE'RE TRYING TO STUDY: MARS.

495
00:21:13,400 --> 00:21:15,733
AND THAT'S MOUNT SHARP,
WHICH THE "CURIOSITY" ROVER

496
00:21:15,733 --> 00:21:18,200
IS IN THE PROCESS OF CLIMBING,

497
00:21:18,200 --> 00:21:20,366
GETTING BACK
REALLY EXCITING DATA

498
00:21:20,366 --> 00:21:21,933
FROM ITS MULTIPLE
INSTRUMENTS,

499
00:21:21,933 --> 00:21:24,066

TRYING TO GET
AT THIS QUESTION

500
00:21:24,066 --> 00:21:26,266
OF WERE THERE HABITABLE
ENVIRONMENTS

501
00:21:26,266 --> 00:21:27,700
ON THE SURFACE OF MARS,
AND IF SO,

502
00:21:27,700 --> 00:21:29,733
HOW LONG DID THEY PERSIST?

503
00:21:29,733 --> 00:21:31,866
AND THE NEWS THAT'S COME BACK
FROM "CURIOSITY"

504
00:21:31,866 --> 00:21:33,600
HAS BEEN EXCITING, OKAY?

505
00:21:33,600 --> 00:21:36,866
WE'VE KNOWN FOR A LONG TIME
THERE WAS WATER ON MARS.

506
00:21:36,866 --> 00:21:39,666
SOME OF THE RESULTS FROM
"SPIRIT" AND "OPPORTUNITY"

507
00:21:39,666 --> 00:21:41,233
SAID, WELL, SOME OF THESE
ENVIRONMENTS--

508
00:21:41,233 --> 00:21:43,466
AQUEOUS ENVIRONMENTS
MAYBE WEREN'T ALL THAT--

509
00:21:43,466 --> 00:21:47,800
THAT WELCOMING TO LIFE.

510
00:21:47,800 --> 00:21:50,800
BUT THE ENVIRONMENTS THAT HAVE
BEEN IDENTIFIED AT GALE CRATER

511
00:21:50,800 --> 00:21:53,266
SEEM TO BE, AGAIN,
LONG-LASTING

512
00:21:53,266 --> 00:21:56,566
AND MUCH MORE CONDUCIVE
POTENTIALLY

513
00:21:56,566 --> 00:21:58,400
TO THE FORMATION OF LIFE.

514
00:21:58,400 --> 00:21:59,866
SO WE'VE BEEN REALLY EXCITED
BY THE RESULTS

515
00:21:59,866 --> 00:22:01,433
COMING BACK FROM THAT.

516
00:22:01,433 --> 00:22:04,300
NOT TO MENTION THAT
ONE OF THE INSTRUMENTS ON--

517
00:22:04,300 --> 00:22:06,800
ON "CURIOSITY,"

518
00:22:06,800 --> 00:22:09,133
THE MASS SPECTROMETER,

519
00:22:09,133 --> 00:22:12,200
HAS ACTUALLY BEEN ABLE TO GET
SOME EXPOSURE AGE DATING,

520
00:22:12,200 --> 00:22:14,333
WHICH IS THE FIRST AGE DATING
WE'VE BEEN ABLE TO DO

521
00:22:14,333 --> 00:22:15,733
ON A PLANETARY SURFACE.

522
00:22:15,733 --> 00:22:18,166
AGE DATING IS REALLY IMPORTANT
TO GEOLOGISTS,

523
00:22:18,166 --> 00:22:21,566
BECAUSE IT ALLOWS YOU TO PUT
ABSOLUTE DATES ON THINGS

524
00:22:21,566 --> 00:22:22,966
RATHER THAN SAYING,

525
00:22:22,966 --> 00:22:24,566
"OKAY, THESE ROCKS
ARE OLDER THAN THESE ROCKS,

526
00:22:24,566 --> 00:22:26,300
"BUT I DON'T REALLY KNOW
WHEN THEY FORMED

527
00:22:26,300 --> 00:22:28,466
OR HOW LONG THEY TOOK
TO FORM."

528
00:22:28,466 --> 00:22:32,000
AGE DATING ALLOWS YOU TO PUT
A SPECIFIC DATE ON THE ROCKS

529
00:22:32,000 --> 00:22:34,633
AND ACTUALLY START TO UNDERSTAND
HOW LONG HAVE THESE ROCKS,

530
00:22:34,633 --> 00:22:36,933
FOR EXAMPLE, BEEN EXPOSED
TO COSMIC RADIATION?

531

00:22:36,933 --> 00:22:38,566
WHEN DID THEY FORM?

532
00:22:38,566 --> 00:22:40,500
A CRITICAL TOOL
THAT WE'VE NEVER HAD

533
00:22:40,500 --> 00:22:42,666
ON A PLANETARY SURFACE
UNTIL "CURIOSITY."

534
00:22:42,666 --> 00:22:44,433
SO REALLY EXCITING.

535
00:22:44,433 --> 00:22:48,566
BUT THE OTHER PLACES
THAT WE GO IN OUR SOLAR SYSTEM

536
00:22:48,566 --> 00:22:53,200
IS UP THERE
IN THE UPPER RIGHT.

537
00:22:53,200 --> 00:22:55,633
EUROPA. EUROPA'S A MOON
OF JUPITER.

538
00:22:55,633 --> 00:22:57,500
IT HAS AN ICY CRUST.

539
00:22:57,500 --> 00:22:59,866
AND UNDER THAT ICY CRUST,

540
00:22:59,866 --> 00:23:02,033
WE KNOW THERE'S A LIQUID
WATER OCEAN.

541
00:23:02,033 --> 00:23:04,000
AND UNDER AT THE BASE
OF THAT OCEAN

542
00:23:04,000 --> 00:23:06,800
THERE'S A LARGELY
SILICATE CORE.

543
00:23:06,800 --> 00:23:10,500
NOW, EUROPA IS OBVIOUSLY,
AS I SAID,

544
00:23:10,500 --> 00:23:11,866
IN ORBIT AROUND JUPITER.

545
00:23:11,866 --> 00:23:15,000
JUPITER HAS A MASSIVE--
IS EXTREMELY MASSIVE,

546
00:23:15,000 --> 00:23:18,266
SO IT'S ALWAYS PULLING,
PULLING, PULLING ON EUROPA.

547
00:23:18,266 --> 00:23:22,400
IT IS ALWAYS TUGGING, ALSO,
HUGE TIDES ON IO,

548
00:23:22,400 --> 00:23:23,733
ONE OF JUPITER'S
OTHER MOONS.

549
00:23:23,733 --> 00:23:26,800
AND IO IS COVERED
WITH VOLCANOES.

550
00:23:26,800 --> 00:23:29,366
OKAY, EUROPA IS A LITTLE FURTHER
OUT FROM JUPITER,

551
00:23:29,366 --> 00:23:32,333
BUT STILL CLOSE ENOUGH
THAT IT HAS HUGE TIDAL EFFECTS,

552

00:23:32,333 --> 00:23:36,166
UP TO 30 METERS
FROM THAT PULL OF JUPITER.

553
00:23:36,166 --> 00:23:39,766
OKAY, SO THAT SILICATE CORE
INSIDE OF EUROPA

554
00:23:39,766 --> 00:23:41,933
IS CONSTANTLY MOVING AROUND.

555
00:23:41,933 --> 00:23:44,766
THAT MOVING AROUND CREATES
FRICTIONAL HEAT,

556
00:23:44,766 --> 00:23:48,000
ENOUGH TO MELT,
ENOUGH TO CAUSE VOLCANISM.

557
00:23:48,000 --> 00:23:50,100
OKAY, SO THINK OF THAT
ICY CRUST,

558
00:23:50,100 --> 00:23:51,900
A BIG, THICK WATER OCEAN,

559
00:23:51,900 --> 00:23:57,166
AND THEN AT THE BOTTOM OF THAT
LIQUID OCEAN: VOLCANOES.

560
00:23:57,166 --> 00:23:59,200
ALL KINDS OF VOLCANIC VENTS.

561
00:23:59,200 --> 00:24:03,566
VOLCANIC VENTS PRODUCE HEAT,
THEY PRODUCE LOTS OF NUTRIENTS,

562
00:24:03,566 --> 00:24:04,933
ALL KINDS OF MINERALS.

563
00:24:04,933 --> 00:24:06,933
A GREAT ENVIRONMENT,
POTENTIALLY,

564
00:24:06,933 --> 00:24:08,700
FOR THE FORMATION OF LIFE.

565
00:24:08,700 --> 00:24:11,933
AND SO ONE OF OUR
PRIMARY TARGETS--

566
00:24:11,933 --> 00:24:13,533
IN FACT, JUST LAST WEEK

567
00:24:13,533 --> 00:24:17,000
WE RELEASED AN ANNOUNCEMENT
OF OPPORTUNITY

568
00:24:17,000 --> 00:24:19,833
FOR PEOPLE TO START THINKING
ABOUT INSTRUMENTS

569
00:24:19,833 --> 00:24:21,533
FOR THE NEXT MISSION
TO EUROPA,

570
00:24:21,533 --> 00:24:24,466
WHICH WE HOPE WILL TAKE PLACE
IN THE 2020s.

571
00:24:24,466 --> 00:24:28,566
ON THE BOTTOM,
YOU SEE ENCELADUS,

572
00:24:28,566 --> 00:24:31,266
WHICH IS ANOTHER MOON OF SATURN,
LIKE TITAN.

573
00:24:31,266 --> 00:24:34,166

ENCELADUS ALSO HAS
A LIQUID OCEAN,

574
00:24:34,166 --> 00:24:36,233
BUT IN THIS CASE WE THINK
IT'S A LOT SMALLER,

575
00:24:36,233 --> 00:24:39,500
MORE LIKE A LIQUID SEA
UNDERNEATH ITS ICY CRUST.

576
00:24:39,500 --> 00:24:42,266
SO, AGAIN, NO REAL ATMOSPHERE,
ICY CRUST,

577
00:24:42,266 --> 00:24:46,633
SUB-SURFACE--SMALL,
IN THIS CASE, PROBABLY, SEA.

578
00:24:46,633 --> 00:24:50,333
ENCELADUS IS ALSO BEING PULLED
ON BY SATURN,

579
00:24:50,333 --> 00:24:52,933
AND THAT CAUSES CRACKS
IN THE SURFACE OF ENCELADUS.

580
00:24:52,933 --> 00:24:56,033
AND IT TURNS OUT YOU HAVE
GEYSER-LIKE ERUPTIONS

581
00:24:56,033 --> 00:24:58,266
COMING FROM THAT
SUB-SURFACE OCEAN,

582
00:24:58,266 --> 00:25:00,600
SPEWING MATERIAL OUT.

583
00:25:00,600 --> 00:25:02,466
LUCKILY WITH

THE "CASSINI" SPACECRAFT,

584
00:25:02,466 --> 00:25:04,833
WE WERE ACTUALLY ABLE
TO FLY THROUGH THOSE PLUMES,

585
00:25:04,833 --> 00:25:08,833
SO WE KNOW THEY'RE PARTIALLY
WATER AND WATER ICE.

586
00:25:08,833 --> 00:25:10,633
BUT WE ALSO KNOW
THERE'S ALL KINDS

587
00:25:10,633 --> 00:25:14,566
OF COMPLEX ORGANIC COMPOUNDS
COMING OUT FROM THE INTERIOR.

588
00:25:14,566 --> 00:25:16,600
NOW, WE DON'T KNOW
EXACTLY WHAT THEY ARE,

589
00:25:16,600 --> 00:25:18,500
BECAUSE THE MASS SPECTROMETER
ON "CASSINI"

590
00:25:18,500 --> 00:25:20,100
REALLY WASN'T DESIGNED
TO BE ABLE

591
00:25:20,100 --> 00:25:21,933
TO SPECIFY EXACTLY
WHAT THEY ARE,

592
00:25:21,933 --> 00:25:24,966
BUT WE KNOW THEY'RE COMPLEX
CARBON COMPOUNDS.

593
00:25:24,966 --> 00:25:27,366
SO ENCELADUS

IS ANOTHER TARGET

594
00:25:27,366 --> 00:25:29,133
POTENTIALLY TO GO TO
IN THE FUTURE

595
00:25:29,133 --> 00:25:32,866
TO REALLY UNDERSTAND HOW MANY
PLACES IN OUR OWN SOLAR SYSTEM

596
00:25:32,866 --> 00:25:35,300
COULD BE CONDUCIVE TO LIFE.

597
00:25:35,300 --> 00:25:38,533
IN THE UPPER LEFT,
YOU SEE TITAN.

598
00:25:38,533 --> 00:25:40,366
AGAIN, I TALK A LOT
ABOUT TITAN,

599
00:25:40,366 --> 00:25:43,333
WHICH NATHALIE CABROL
WILL APPRECIATE.

600
00:25:43,333 --> 00:25:47,266
BUT NATHALIE AND I ARE
PARTICULARLY INTERESTED IN TITAN

601
00:25:47,266 --> 00:25:50,333
BECAUSE OF THE FACT THAT IT HAS
THESE SEAS ON ITS SURFACE.

602
00:25:50,333 --> 00:25:53,000
VERY LONG-LASTING.
WE THINK THEY ACTUALLY PERSIST

603
00:25:53,000 --> 00:25:55,533
FOR LIKELY TENS OF THOUSANDS
OF YEARS.

604
00:25:55,533 --> 00:25:58,600
THE SEAS, AGAIN, NOT WATER--
LIQUID ETHANE AND METHANE.

605
00:25:58,600 --> 00:26:01,733
ALL KINDS OF COMPLICATED
ORGANIC COMPOUNDS,

606
00:26:01,733 --> 00:26:04,333
SOME LIKE PLASTICS, ARE FORMING
IN THE ATMOSPHERE OF TITAN.

607
00:26:04,333 --> 00:26:06,766
THEY FORM SOLID PARTICLES
CALLED THOLINS.

608
00:26:06,766 --> 00:26:09,266
THOSE THOLINS RAIN DOWN
INTO THE SEAS

609
00:26:09,266 --> 00:26:12,566
AND PERSIST IN THOSE SEAS
FOR PROBABLY, AGAIN,

610
00:26:12,566 --> 00:26:14,133
VERY LONG PERIODS OF TIME.

611
00:26:14,133 --> 00:26:17,300
OKAY, THERE'S NO LIQUID WATER
AND IT'S COLD.

612
00:26:17,300 --> 00:26:18,966
AGAIN, EXTREMELY COLD.

613
00:26:18,966 --> 00:26:22,233
SO COULD YOU HAVE ANY--
ENOUGH ENERGY

614

00:26:22,233 --> 00:26:25,033
THAT WOULD LEAD TOWARDS ANYTHING
THAT LOOKED LIKE LIFE?

615
00:26:25,033 --> 00:26:26,633
COULD YOU ONLY GET
SOME OF THE WAY THERE

616
00:26:26,633 --> 00:26:28,066
BUT NOT ALL
OF THE WAY THERE?

617
00:26:28,066 --> 00:26:29,733
WE HAVE NO IDEA.

618
00:26:29,733 --> 00:26:31,833
BUT IF YOU REALLY WANT TO PUSH
ON THE LIMITS TO LIFE,

619
00:26:31,833 --> 00:26:34,266
AFTER WE EXPLORE THE PLACES
WHERE WE THINK ARE MORE LIKELY

620
00:26:34,266 --> 00:26:36,033
BECAUSE THERE'S LIQUID WATER,

621
00:26:36,033 --> 00:26:39,666
TITAN WOULD CERTAINLY
BE HIGH ON THE LIST.

622
00:26:40,966 --> 00:26:42,400
THE OTHER REASON
WE'RE PARTICULARLY EXCITED

623
00:26:42,400 --> 00:26:44,133
ABOUT EUROPA RIGHT NOW

624
00:26:44,133 --> 00:26:47,766
IS THIS IS A MOSAIC
OF THE SOUTHERN--

625
00:26:47,766 --> 00:26:49,700
NEAR THE SOUTHERN POLAR REGION.

626
00:26:49,700 --> 00:26:53,033
AND FROM SOME OF THOSE CRACKS
THAT YOU SEE

627
00:26:53,033 --> 00:26:55,766
HERE NEAR THE SOUTH POLE,

628
00:26:55,766 --> 00:26:57,666
HUBBLE TOOK SOME
OBSERVATIONS.

629
00:26:57,666 --> 00:26:59,666
WELL, OKAY,
A SCIENTIST MADE HUBBLE

630
00:26:59,666 --> 00:27:02,166
TAKE SOME OBSERVATIONS
LAST YEAR

631
00:27:02,166 --> 00:27:04,400
OF THAT REGION.

632
00:27:04,400 --> 00:27:08,500
AND WHAT THEY SAW WAS A HYDROGEN
AND OXYGEN CLOUD, BASICALLY,

633
00:27:08,500 --> 00:27:11,433
AROUND THAT REGION
OF EUROPA,

634
00:27:11,433 --> 00:27:14,633
SEEMINGLY INDICATING WHAT
ACTUALLY A BUNCH OF SCIENTISTS

635
00:27:14,633 --> 00:27:16,166

HAD BEEN PREDICTING
FOR SOME TIME.

636
00:27:16,166 --> 00:27:18,300
WHEN THEY SAW THOSE PLUMES
ON ENCELADUS

637
00:27:18,300 --> 00:27:21,966
THEY THOUGHT, YOU KNOW,
EUROPA'S GOT ALL THESE CRACKS.

638
00:27:21,966 --> 00:27:24,266
EUROPA'S IN THIS SIMILAR
SITUATION,

639
00:27:24,266 --> 00:27:26,566
BEING TUGGED ON
JUST LIKE ENCELADUS IS.

640
00:27:26,566 --> 00:27:28,600
MAYBE WE HAVE SIMILAR PLUMES

641
00:27:28,600 --> 00:27:32,233
COMING OUT
OF THE POLE OF EUROPA.

642
00:27:32,233 --> 00:27:34,166
THE PLANET
WAS ACTUALLY ALSO

643
00:27:34,166 --> 00:27:37,900
AT ABOUT THE RIGHT POINT IN ITS
ORBIT AROUND JUPITER,

644
00:27:37,900 --> 00:27:40,200
WHERE YOU'D EXPECT IT TO BE
REALLY BEING YANKED ON.

645
00:27:40,200 --> 00:27:43,166
SO THAT WOULD BE MAYBE THE

MAXIMUM TIME OF CRACK OPENINGS,

646
00:27:43,166 --> 00:27:46,166
WHEN YOU WOULD EXPECT A PLUME
TO BE FORMING.

647
00:27:46,166 --> 00:27:48,333
NOW, THEY'VE LOOKED AGAIN AND
THEY HAVEN'T SEEN THE PLUMES,

648
00:27:48,333 --> 00:27:50,833
SO THERE'S A WHOLE BUNCH
OF OBSERVATIONS PLANNED

649
00:27:50,833 --> 00:27:53,200
TO GO BACK AND LOOK AGAIN
AND SAY,

650
00:27:53,200 --> 00:27:55,700
"CAN WE SEE THESE PLUMES?"
"CAN WE UNDERSTAND?"

651
00:27:55,700 --> 00:27:57,766
NOW OBVIOUSLY THAT WOULD
HUGELY AFFECT

652
00:27:57,766 --> 00:28:01,233
WHAT YOU MIGHT DO NEXT
AT EUROPA,

653
00:28:01,233 --> 00:28:02,700
BECAUSE FOR A LONG TIME

654
00:28:02,700 --> 00:28:04,166
WE'VE CERTAINLY BEEN WONDERING,
FOR EXAMPLE,

655
00:28:04,166 --> 00:28:07,700
THERE'S THIS KIND OF ORANGEY
BROWN STUFF ON THE SURFACE.

656
00:28:07,700 --> 00:28:09,066
WE DON'T KNOW
WHAT ITS COMPOSITION IS.

657
00:28:09,066 --> 00:28:11,333
THAT'S ONE THING AN ORBITER
OR A FLY--

658
00:28:11,333 --> 00:28:13,866
A MISSION THAT WAS IN JUPITER
ORBIT GOING BY EUROPA

659
00:28:13,866 --> 00:28:14,866
WOULD CERTAINLY GET AT,

660
00:28:14,866 --> 00:28:16,333
WHAT'S THE CHEMISTRY
OF THAT.

661
00:28:16,333 --> 00:28:18,666
BUT BECAUSE OF THAT HARSH
RADIATION ENVIRONMENT,

662
00:28:18,666 --> 00:28:21,733
EXTREMELY HARSH RADIATION
ENVIRONMENT BECAUSE OF JUPITER

663
00:28:21,733 --> 00:28:23,500
BEING RIGHT THERE,
WE DON'T REALLY THINK ANYTHING

664
00:28:23,500 --> 00:28:25,200
COULD LIVE ON THE SURFACE
OF EUROPA.

665
00:28:25,200 --> 00:28:28,100
SO ANYTHING THAT'S LIVING
WOULD LIKELY BE SUBSURFACE.

666
00:28:28,100 --> 00:28:31,066
OKAY, YOU THINK, OKAY, FROM AN
OBSERVATIONAL POINT OF VIEW,

667
00:28:31,066 --> 00:28:33,266
HOW AM I EVER GOING TO GET
AT THE COMPOSITION

668
00:28:33,266 --> 00:28:35,133
OF THAT SUBSURFACE OCEAN
IF ALL I CAN DO

669
00:28:35,133 --> 00:28:37,466
IS LOOK AT THE TOP
OF THE ICY CRUST?

670
00:28:37,466 --> 00:28:40,400
WELL, WE'RE CERTAINLY INTERESTED
IN WHAT THAT MATERIAL IS

671
00:28:40,400 --> 00:28:42,333
ON THE OUTSIDE.

672
00:28:42,333 --> 00:28:45,733
BUT THE FACT THAT EUROPA
MIGHT ACTUALLY BE SPITTING AT US

673
00:28:45,733 --> 00:28:48,566
SAMPLES OF ITS INTERIOR OCEAN

674
00:28:48,566 --> 00:28:51,533
IS EXTREMELY EXCITING FROM
AN EXPLORATION POINT OF VIEW,

675
00:28:51,533 --> 00:28:53,600
BECAUSE IT MEANS WE CAN
ACCESS THAT MATERIAL

676
00:28:53,600 --> 00:28:57,566

AND ANALYZE IT WITHOUT HAVING
TO DO ALL THE COOL THINGS

677
00:28:57,566 --> 00:28:59,333
THAT YOU READ ABOUT
THAT PEOPLE THINK ABOUT,

678
00:28:59,333 --> 00:29:01,900
LIKE MELTING DOWN THROUGH
10 KILOMETERS OF ICE,

679
00:29:01,900 --> 00:29:05,233
AND PUTTING SUBMARINES
INTO THE OCEANS ON EUROPA.

680
00:29:05,233 --> 00:29:07,466
COOL THINGS TO THINK ABOUT,

681
00:29:07,466 --> 00:29:10,600
BUT IF I WANT THIS QUESTION
ANSWERED IN MY LIFETIME,

682
00:29:10,600 --> 00:29:12,866
MY BET IS WE'RE GOING TO HAVE
TO REALLY ANALYZE THE MATERIAL

683
00:29:12,866 --> 00:29:14,500
COMING OUT IN THOSE PLUMES.

684
00:29:14,500 --> 00:29:19,500
SO REALLY EXCITING
WORK TO DO AT EUROPA.

685
00:29:19,500 --> 00:29:20,766
[coughs]

686
00:29:20,766 --> 00:29:22,466
BUT IN THE MEANTIME,

687

00:29:22,466 --> 00:29:25,866
WE'RE DOING ALL THIS EXCITING
WORK AT MARS.

688
00:29:25,866 --> 00:29:28,366
AND THIS IS JUST FIVE
OF THE EIGHT PLACES WE'VE LANDED

689
00:29:28,366 --> 00:29:30,133
ON THE SURFACE OF MARS.

690
00:29:30,133 --> 00:29:32,766
AND WHEN WE THINK YOU HEAR
NASA MORE AND MORE

691
00:29:32,766 --> 00:29:36,233
TALKING ABOUT...
ABOUT HUMANS TO MARS,

692
00:29:36,233 --> 00:29:39,366
THAT IT'S REALLY THE DIRECTION
WE WANT TO GO,

693
00:29:39,366 --> 00:29:40,700
IT'S THE ULTIMATE
DESTINATION

694
00:29:40,700 --> 00:29:42,733
FOR GETTING HUMANS
DOWN ON THE SURFACE.

695
00:29:42,733 --> 00:29:44,166
AND JOHN GRUNSFELD,

696
00:29:44,166 --> 00:29:46,033
THE ASSOCIATE ADMINISTRATOR
FOR SCIENCE,

697
00:29:46,033 --> 00:29:47,466
LIKES TO REMIND EVERYBODY

698
00:29:47,466 --> 00:29:50,266
WE'RE ALREADY DEEP IN
THE PROCESS OF EXPLORING MARS.

699
00:29:50,266 --> 00:29:52,600
THIS IS NOT SOMETHING NEW
THAT'S NASA DOING.

700
00:29:52,600 --> 00:29:55,166
THE HUMANS WOULD BE FOLLOWING
IN THE FOOTSTEPS

701
00:29:55,166 --> 00:29:58,700
OF THE EXTENSIVE WORK THAT
WE'VE BEEN DOING ROBOTICALLY,

702
00:29:58,700 --> 00:30:01,866
LAYING THE CASE TO ME,
SCIENTIFICALLY,

703
00:30:01,866 --> 00:30:03,733
FOR SOME OF THE REASONS
THAT IT'S SO IMPORTANT

704
00:30:03,733 --> 00:30:06,666
TO ACTUALLY GET SCIENTISTS
DOWN ON THE SURFACE OF MARS.

705
00:30:06,666 --> 00:30:09,866
LOTS OF DIFFERENT ENVIRONMENTS
THAT WE'VE EXPLORED,

706
00:30:09,866 --> 00:30:14,100
BOTH IN SITU AND REMOTELY.

707
00:30:14,100 --> 00:30:18,333
AND THE MORE RESEARCH WE DO,
THE MORE WE'RE ABLE TO REFINE

708
00:30:18,333 --> 00:30:21,066
WHERE ARE THE BEST PLACES
TO ACTUALLY GO AND EXPLORE,

709
00:30:21,066 --> 00:30:23,100
TO TRY TO REALLY PUSH
AT THIS QUESTION

710
00:30:23,100 --> 00:30:26,266
OF, "DID LIFE EVOLVE
ON THE SURFACE?"

711
00:30:26,266 --> 00:30:28,666
AND SO WE THINK
OF THE EVENTUALITY.

712
00:30:28,666 --> 00:30:30,300
IN MY MIND, AGAIN,

713
00:30:30,300 --> 00:30:34,333
BEING SOMEBODY WHO VALUES
FIELD GEOLOGY HUGELY,

714
00:30:34,333 --> 00:30:36,866
IF WE'RE EVER REALLY GOING
TO RESOLVE THIS QUESTION,

715
00:30:36,866 --> 00:30:39,533
I ARGUE IT'S GOING TO TAKE
ASTROBIOLOGISTS

716
00:30:39,533 --> 00:30:41,033
ON THE SURFACE OF MARS,

717
00:30:41,033 --> 00:30:42,966
PROBABLY WITH A LABORATORY
RIGHT THERE,

718
00:30:42,966 --> 00:30:46,366

YOU KNOW,
WORKING IN A LAB ON MARS

719
00:30:46,366 --> 00:30:49,200
TO ACTUALLY DEMONSTRATE, YES,
LIFE EVOLVED.

720
00:30:49,200 --> 00:30:51,666
BECAUSE I THINK IT'S GOING TO BE
PRETTY HARD TO FIND.

721
00:30:51,666 --> 00:30:52,966
AND I THINK THERE'LL BE
A HUGE DEBATE

722
00:30:52,966 --> 00:30:54,700
IN THE SCIENTIFIC
COMMUNITY OVER

723
00:30:54,700 --> 00:30:56,266
"IS THIS LIFE?",
"IS IT NOT LIFE?",

724
00:30:56,266 --> 00:30:58,500
"IS IT THE BUILDING BLOCKS
OF LIFE?"

725
00:30:58,500 --> 00:31:02,400
SO, AGAIN, AS A FIELD GEOLOGIST,
I'M ANXIOUS TO,

726
00:31:02,400 --> 00:31:05,500
AS SOON AS WE CAN,
GET THOSE SCIENTISTS

727
00:31:05,500 --> 00:31:08,966
ONTO THE SURFACE OF MARS
DOING WHAT WE DO BEST:

728
00:31:08,966 --> 00:31:10,800

EXPLORING IN SITU.

729
00:31:10,800 --> 00:31:14,066
AN EXCITING FUTURE
TO THINK ABOUT.

730
00:31:14,066 --> 00:31:17,033
AND HOPEFULLY, AGAIN,
AS EARLY AS THE 2030s,

731
00:31:17,033 --> 00:31:19,866
GETTING US DOWN
ONTO THE SURFACE.

732
00:31:21,466 --> 00:31:24,366
NOW YOU CAN SAY,
"OKAY, CAN WE DO THIS?"

733
00:31:24,366 --> 00:31:26,933
AND I--, I--

734
00:31:26,933 --> 00:31:29,200
SOME OF YOU KNOW,
MY FATHER WORKED FOR NASA,

735
00:31:29,200 --> 00:31:32,166
AND I FOUND AN INTERVIEW WITH
HIM THAT WAS DONE IN THE 1980s.

736
00:31:32,166 --> 00:31:34,633
AND HE WAS SAYING--
HE WAS REALLY EXCITED

737
00:31:34,633 --> 00:31:35,733
BECAUSE IN THE NEXT
20 YEARS,

738
00:31:35,733 --> 00:31:37,500
WE WERE GOING TO PUT PEOPLE
ON MARS.

739
00:31:37,500 --> 00:31:39,866
AND IT'S LIKE, AH,
THIS IS DEPRESSING.

740
00:31:39,866 --> 00:31:44,400
BUT, YOU KNOW, I'M CONFIDENT
THAT IF WE PUT OUR WILL TO IT,

741
00:31:44,400 --> 00:31:45,900
YOU KNOW, WE CAN DO IT.

742
00:31:45,900 --> 00:31:50,733
AND WHAT I LIKE IS WE HAVE THIS
FORMULATED ROAD TO MARS,

743
00:31:50,733 --> 00:31:53,866
AND WE'RE WELL ON THE WAY TO
ATTACKING BITS OF THIS PROBLEM.

744
00:31:53,866 --> 00:31:57,200
TO START AT MARS, AGAIN,
WE HAVE--

745
00:31:57,200 --> 00:31:58,733
I DON'T WANT TO CALL IT
A FLOTILLA.

746
00:31:58,733 --> 00:32:00,833
THAT SOUNDS, WELL,
FIRST OF ALL, NAUTICAL.

747
00:32:00,833 --> 00:32:05,100
BUT ANYWAY,
WE HAVE THESE WONDERFUL

748
00:32:05,100 --> 00:32:08,500
SPACECRAFT ASSETS IN ORBIT,
ON THE GROUND,

749
00:32:08,500 --> 00:32:11,800
IDENTIFYING WHERE THE BEST
SCIENCE IS,

750
00:32:11,800 --> 00:32:14,233
REALLY GETTING AT A VARIETY
OF SCIENTIFIC QUESTIONS.

751
00:32:14,233 --> 00:32:16,333
BUT, AGAIN, CENTERING AROUND
THIS QUESTION OF,

752
00:32:16,333 --> 00:32:18,700
"DID LIFE EVOLVE ON MARS?"

753
00:32:18,700 --> 00:32:20,900
BUT ALSO DOING
A LOT OF THE CHARACTERIZATION

754
00:32:20,900 --> 00:32:23,666
OF THE MARTIAN ENVIRONMENT
THAT WE NEED TO DO.

755
00:32:23,666 --> 00:32:25,900
AND DON'T GET ME WRONG,
WE NEED TO DO A LOT MORE--

756
00:32:25,900 --> 00:32:28,433
THINGS LIKE WHAT'S THE EXACT
NATURE OF THE DUST ON MARS

757
00:32:28,433 --> 00:32:29,933
THAT COULD BE HAZARDOUS
TO HUMANS

758
00:32:29,933 --> 00:32:31,533
TRYING TO WORK
ON THE SURFACE--

759

00:32:31,533 --> 00:32:34,533
BUT TRYING TO FILL WHAT WE CALL
THE STRATEGIC KNOWLEDGE GAPS

760
00:32:34,533 --> 00:32:39,533
TO GET READY TO SAFELY SEND
HUMANS TO WORK ON MARS

761
00:32:39,533 --> 00:32:42,866
AND RETURN SAFELY BACK
TO THE PLANET.

762
00:32:42,866 --> 00:32:45,566
IN THE MEANTIME,
WITH HUMANS,

763
00:32:45,566 --> 00:32:47,500
WE'RE DOING THE WORK
THAT WE NEED TO DO

764
00:32:47,500 --> 00:32:50,166
IN WHAT WE CALL
THE EARTH RELIANT.

765
00:32:50,166 --> 00:32:51,866
JUST UP ON THE INTERNATIONAL
SPACE STATION,

766
00:32:51,866 --> 00:32:54,466
WHERE WE CAN EASILY AND SAFELY
RETURN HOME TO EARTH,

767
00:32:54,466 --> 00:32:57,300
WE'RE DOING THIS BROAD RANGE
OF RESEARCH

768
00:32:57,300 --> 00:33:01,466
TO UNDERSTAND THE EFFECTS OF
MICROGRAVITY ON THE HUMAN BODY.

769

00:33:01,466 --> 00:33:05,400
AND MOST OF YOU KNOW HUGE--
A LOT OF HUGE NEGATIVE EFFECTS.

770
00:33:05,400 --> 00:33:08,166
MUSCLE WASTING,
BONE DENSITY LOSS,

771
00:33:08,166 --> 00:33:09,866
RAISE OF INTRACRANIAL PRESSURE

772
00:33:09,866 --> 00:33:11,400
SO YOU GET PRESSURE
ON YOUR EYES.

773
00:33:11,400 --> 00:33:12,966
IT AFFECTS
YOUR OPTIC NERVE,

774
00:33:12,966 --> 00:33:15,066
EFFECTS ON YOUR
IMMUNE SYSTEM--

775
00:33:15,066 --> 00:33:17,400
ALL OF THESE THINGS
THAT WE ACTUALLY HAVE

776
00:33:17,400 --> 00:33:22,400
A REALLY DETAILED LIST
OF HERE ARE THE RISKS TO HUMANS

777
00:33:22,400 --> 00:33:25,800
FOR A TRIP TO MARS
THAT WE NEED TO DO RESEARCH,

778
00:33:25,800 --> 00:33:29,100
BOTH A MIXTURE OF FUNDAMENTAL
RESEARCH AND MITIGATION EFFORTS,

779
00:33:29,100 --> 00:33:32,466

TO TRY TO MAKE SURE THAT WE CAN
SAFELY SEND HUMANS TO MARS

780
00:33:32,466 --> 00:33:35,800
IN THE NEXT 20 YEARS
AND RETURN THEM HOME AGAIN.

781
00:33:35,800 --> 00:33:39,700
SO A HUGE AMOUNT OF WORK BEING
DONE IN THIS EARTH RELIANT AREA.

782
00:33:39,700 --> 00:33:41,533
NOT TO MENTION
TECHNOLOGY DEVELOPMENT.

783
00:33:41,533 --> 00:33:44,133
MOST OF YOU ARE AWARE,
A COUPLE OF WEEKS AGO,

784
00:33:44,133 --> 00:33:48,200
WE TESTED A SUPERSONIC
PARACHUTE.

785
00:33:48,200 --> 00:33:51,166
AND WE WANT TO DO MORE
WITH TECHNOLOGY TESTING,

786
00:33:51,166 --> 00:33:55,000
BOTH FROM THE ISS
AND HERE ON THE GROUND,

787
00:33:55,000 --> 00:33:57,766
JUST TRY TO START BUYING DOWN
SOME OF THE BIG RISKS,

788
00:33:57,766 --> 00:33:59,600
LIKE ENTRY, DESCENT,
AND LANDING

789
00:33:59,600 --> 00:34:01,800

THAT WE HAVE TO OVERCOME

790
00:34:01,800 --> 00:34:04,200
TO BE ABLE TO SEND HUMANS
SAFELY TO MARS.

791
00:34:04,200 --> 00:34:06,233
AND THEN, ULTIMATELY,
WE WANT TO GO OUT

792
00:34:06,233 --> 00:34:10,100
TO WHAT WE--BILL GERSTENMAIER
CALLS THE PROVING GROUND

793
00:34:10,100 --> 00:34:12,033
OUT IN THE VICINITY
OF THE MOON,

794
00:34:12,033 --> 00:34:15,000
WHERE WE CAN START GOING
THAT NEXT STEP

795
00:34:15,000 --> 00:34:18,000
IN A MORE HAZARDOUS RADIATION
ENVIRONMENT,

796
00:34:18,000 --> 00:34:20,766
IN A MORE NON-EARTH RELIANT,

797
00:34:20,766 --> 00:34:24,000
BUT "STILL ABLE TO GET HOME
IN A FEW DAYS" ENVIRONMENT.

798
00:34:24,000 --> 00:34:26,133
TO, AGAIN,
PUSH THESE TECHNOLOGIES,

799
00:34:26,133 --> 00:34:30,766
PUSH DEVELOPING HABITATS,
PUSH EXTRA VEHICLE ACTI--

800
00:34:30,766 --> 00:34:33,700
EXTRAVEHICULAR ACTIVITY,
ECLISS--

801
00:34:33,700 --> 00:34:36,933
ALL THESE DIFFERENT SYSTEMS
THAT WE NEED TO USE

802
00:34:36,933 --> 00:34:39,366
TO GET HUMANS TO MARS.

803
00:34:39,366 --> 00:34:42,433
BUT THE WORK THAT WE'RE DOING ON
THE INTERNATIONAL SPACE STATION

804
00:34:42,433 --> 00:34:43,666
I THINK IS PARTICULARLY
CRITICAL.

805
00:34:43,666 --> 00:34:46,266
WE JUST GOT EXTENDED
THROUGH 2024.

806
00:34:46,266 --> 00:34:48,300
A CRITICAL TIME PERIOD
FOR SCIENTISTS.

807
00:34:48,300 --> 00:34:50,733
IF YOU WANT SCIENTISTS OR,
FOR EXAMPLE, COMMERCIAL ENTITIES

808
00:34:50,733 --> 00:34:53,633
TO BE ABLE TO SAY, "HOW CAN I
REALLY USE THIS AS A PLATFORM?"

809
00:34:53,633 --> 00:34:56,166
HAVING THAT EXTENSION
OUT TO 2024

810
00:34:56,166 --> 00:34:58,800
GIVES SOMEBODY
THE RELIABILITY TO SAY,

811
00:34:58,800 --> 00:35:00,600
"I CAN DO A SCIENTIFIC
EXPERIMENT,

812
00:35:00,600 --> 00:35:03,300
THEN I CAN FOLLOW IT UP,
THEN I CAN FOLLOW IT UP AGAIN."

813
00:35:03,300 --> 00:35:06,200
SO HAVING THAT STABILITY
OF THE STATION OUT TO '24,

814
00:35:06,200 --> 00:35:08,000
I THINK IS REALLY CRITICAL.

815
00:35:08,000 --> 00:35:12,533
WE ARE WITH COMMERCIAL CARGO
REALLY COMING ONLINE.

816
00:35:12,533 --> 00:35:14,866
WE'RE ABLE TO START
MORE AND MORE REGULARLY

817
00:35:14,866 --> 00:35:16,533
HAVING REGULAR UP AND DOWN--

818
00:35:16,533 --> 00:35:18,700
WELL, UPMASS MOSTLY,
HOPEFULLY SOON BETTER DOWNMASS

819
00:35:18,700 --> 00:35:20,833
COMING FROM THE STATION.

820
00:35:20,833 --> 00:35:24,266
AGAIN, MAKING IT A RELIABLE

ENVIRONMENT FOR SCIENTISTS

821
00:35:24,266 --> 00:35:26,866
TO DO RESEARCH.

822
00:35:26,866 --> 00:35:30,233
SO REALLY EXCITED ABOUT A LOT OF
WORK THAT WE'RE DOING THERE.

823
00:35:30,233 --> 00:35:33,066
AND TODAY I'VE BEEN TALKING
ABOUT SOME OF THE WORK

824
00:35:33,066 --> 00:35:34,533
THAT WE'RE DOING UP ON
THE ISS,

825
00:35:34,533 --> 00:35:36,900
PRIMARILY FOR GETTING READY
TO GO TO MARS.

826
00:35:36,900 --> 00:35:40,366
BUT OBVIOUSLY THERE'S A HUGE
RANGE OF RESEARCH GOING ON

827
00:35:40,366 --> 00:35:43,133
IN OTHER AREAS.
FROM THE COLD ATOM LAB

828
00:35:43,133 --> 00:35:45,766
WE'RE GOING TO BE STUDYING ATOMS
THAT ARE COOLED DOWN

829
00:35:45,766 --> 00:35:48,500
TO ALMOST ABSOLUTE ZERO
AND STUDYING THAT BEHAVIOR--

830
00:35:48,500 --> 00:35:50,600
THAT'S GOING TO GO UP
IN ABOUT 2018--

831
00:35:50,600 --> 00:35:52,600
TO THE WORK WE DO
IN COMBUSTION,

832
00:35:52,600 --> 00:35:54,633
IDENTIFYING A NEW PHASE
OF COMBUSTION

833
00:35:54,633 --> 00:35:55,900
THAT WE'RE DOING WORK WITH,

834
00:35:55,900 --> 00:35:57,733
ALL THE WORK IN MATERIALS
SCIENCE--

835
00:35:57,733 --> 00:36:00,566
MATERIALS PRODUCTION THAT
IN MICROGRAVITY IS SO DIFFERENT,

836
00:36:00,566 --> 00:36:01,900
CRYSTAL GROWTH--

837
00:36:01,900 --> 00:36:04,500
HUGE RANGE
OF RESEARCH THAT'S GOING ON

838
00:36:04,500 --> 00:36:07,133
ON THE INTERNATIONAL
SPACE STATION EVERY DAY.

839
00:36:07,133 --> 00:36:09,133
REALLY EXCITING.

840
00:36:11,533 --> 00:36:13,133
NOW SOME OF YOU HAVE HEARD ME
TALK BEFORE.

841
00:36:13,133 --> 00:36:16,266

YOU KNOW HOW MUCH I LOVE THIS
IMAGE THAT WAS TAKEN LAST SUMMER

842
00:36:16,266 --> 00:36:18,633
OF THE "CASSINI"--
BY THE "CASSINI" SPACECRAFT,

843
00:36:18,633 --> 00:36:21,600
YOU KNOW, A BILLION KILOMETERS
AWAY FROM EARTH.

844
00:36:21,600 --> 00:36:25,200
LOOKING BACK AT THE EARTH
AND OBSERVING US

845
00:36:25,200 --> 00:36:29,233
IS THIS LITTLE
PALE BLUE DOT IN SPACE,

846
00:36:29,233 --> 00:36:31,600
REDOING THE ORIGINAL
CARL SAGAN IMAGE

847
00:36:31,600 --> 00:36:33,666
THAT WAS DONE
WITH THE "VOYAGER" DATA.

848
00:36:33,666 --> 00:36:35,066
AND I THINK, AGAIN,

849
00:36:35,066 --> 00:36:36,766
IF YOU GO BACK TO THE BEGINNING
OF MY TALK,

850
00:36:36,766 --> 00:36:38,900
TALKING ABOUT HOW WE'RE THIS
PALE BLUE DOT IN SPACE--

851
00:36:38,900 --> 00:36:42,366
YOU KNOW, SUBJECT TO

THE BEHAVIOR OF OUR STAR,

852
00:36:42,366 --> 00:36:45,733
SUBJECT TO OUR OWN MISUSE
OF OUR PLANET--

853
00:36:45,733 --> 00:36:49,166
HERE YOU CAN STEP BACK AND SAY
WHAT A TECHNOLOGICAL FEAT,

854
00:36:49,166 --> 00:36:52,033
THAT WE HAVE GONE OVER A BILLION
MILES--A BILLION KILOMETERS

855
00:36:52,033 --> 00:36:54,733
FROM OUR PLANET
AND CAN LOOK BACK AND STUDY IT.

856
00:36:54,733 --> 00:36:57,700
AND SO IF YOU LOOK--
IF YOU LOOK AT THIS NOW

857
00:36:57,700 --> 00:37:01,300
CLOSE UP FROM THAT SAME IMAGE
OF THE EARTH/MOON SYSTEM,

858
00:37:01,300 --> 00:37:04,133
IT BRINGS UP
ANOTHER QUESTION--

859
00:37:04,133 --> 00:37:08,333
FINDING AN EARTH-LIKE WORLD
AROUND ANOTHER STAR.

860
00:37:08,333 --> 00:37:11,033
HERE, WE'RE ABLE TO LOOK
AT OUR OWN PLANET

861
00:37:11,033 --> 00:37:13,466
AS THOUGH WE WERE

REMOTELY IMAGING

862
00:37:13,466 --> 00:37:15,466
A PLANET AROUND
ANOTHER STAR.

863
00:37:15,466 --> 00:37:18,133
JUST LAST WEEK AT--
I THINK IT WAS LAST WEEK--

864
00:37:18,133 --> 00:37:21,666
AT NASA HEADQUARTERS,
WE HAD A COLLOQUIUM

865
00:37:21,666 --> 00:37:24,866
CALLED "THE SEARCH FOR LIFE
IN THE UNIVERSE."

866
00:37:24,866 --> 00:37:27,166
AND SARA SEAGER WAS THERE.

867
00:37:27,166 --> 00:37:28,866
AND IT WAS REALLY
AMAZING TO ME,

868
00:37:28,866 --> 00:37:31,000
WHICH IS SOMETHING MANY OF YOU
IN THIS AUDIENCE

869
00:37:31,000 --> 00:37:32,733
HAVE PROBABLY THOUGHT OF,
BUT IT REALLY BLEW ME AWAY.

870
00:37:32,733 --> 00:37:36,466
SHE SAID, "YOU KNOW, EVERY TIME
YOU LOOK UP IN THE NIGHT SKY

871
00:37:36,466 --> 00:37:38,866
"AND YOU SEE
ALL THESE STARS,

872
00:37:38,866 --> 00:37:42,766
AROUND EVERY ONE OF THOSE STARS
IS PROBABLY A PLANET."

873
00:37:42,766 --> 00:37:45,966
FROM THE DATA WE'VE FOUND,
FROM BILL'S HARD WORK--

874
00:37:45,966 --> 00:37:48,100
BILL BORUCKI'S HARD WORK
WITH KEPLER,

875
00:37:48,100 --> 00:37:49,833
WHAT WE'VE BEEN ABLE TO KNOW

876
00:37:49,833 --> 00:37:51,600
IS THAT WHEN YOU LOOK UP
IN THAT NIGHT SKY

877
00:37:51,600 --> 00:37:55,966
AND YOU SEE A STAR,
THAT STAR PROBABLY HAS A PLANET.

878
00:37:55,966 --> 00:38:01,566
WHEN WE LOOK INTO THE DEEPEST,
DARKEST PART OF THE SKY,

879
00:38:01,566 --> 00:38:05,166
THIS IS WHAT WE FIND WHEN
WE LOOK AT IT WITH HUBBLE--

880
00:38:05,166 --> 00:38:08,733
TONS AND TONS AND TONS
AND TONS OF GALAXIES,

881
00:38:08,733 --> 00:38:13,433
VERY, VERY YOUNG GALAXIES
VERY, VERY DEEP IN THE UNIVERSE.

882
00:38:13,433 --> 00:38:16,466
AGAIN, THOSE GALAXIES
FULL OF STARS,

883
00:38:16,466 --> 00:38:19,166
SO FULL OF PLANETS.

884
00:38:21,300 --> 00:38:23,733
AND I THINK ONE OF THE MOST
AMAZING THINGS TO ME,

885
00:38:23,733 --> 00:38:26,866
THE MOST EXCITING THINGS
THAT'S COME OUT OF KEPLER

886
00:38:26,866 --> 00:38:28,966
IS NOT JUST SINGLE-PLANET
SYSTEMS,

887
00:38:28,966 --> 00:38:30,866
BUT MULTI-PLANET SYSTEMS,

888
00:38:30,866 --> 00:38:34,900
SOLAR SYSTEMS TO START COMPARING
TO OUR OWN SOLAR SYSTEM.

889
00:38:34,900 --> 00:38:37,233
AND JUST LIKE WITH THE PLANETS,
WHEN YOU GO AND YOU SAY,

890
00:38:37,233 --> 00:38:40,533
"OKAY, HOW DOES A VOLCANO WORK
ON VENUS OR MARS

891
00:38:40,533 --> 00:38:41,933
AS OPPOSED TO HOW IT WORKS
ON EARTH?"

892
00:38:41,933 --> 00:38:44,233

AND YOU START LEARNING ALL KINDS
OF THINGS ABOUT VOLCANISM

893
00:38:44,233 --> 00:38:46,100
THAT YOU DIDN'T EXPECT--

894
00:38:46,100 --> 00:38:48,400
THAT'S HAPPENED
IN SPADES SO FAR

895
00:38:48,400 --> 00:38:50,466
IN OUR STUDY OF
EXTRASOLAR PLANETS.

896
00:38:50,466 --> 00:38:54,900
IT HAS CAUSED THE MODEL
THAT I LEARNED 4,000 YEARS AGO,

897
00:38:54,900 --> 00:38:57,533
AS MY CHILDREN WOULD SAY,
IN GRADUATE SCHOOL

898
00:38:57,533 --> 00:38:59,300
TO BE BASICALLY THROWN OUT--

899
00:38:59,300 --> 00:39:01,533
OUR MODEL OF HOW WE THOUGHT
OUR SOLAR SYSTEM FORMED,

900
00:39:01,533 --> 00:39:04,200
HOW THE PLANETS CONDENSED
FROM THIS TIDY LITTLE CLOUD

901
00:39:04,200 --> 00:39:06,566
WHERE YOU GOT THOSE ROCKY
PLANETS CLOSE TO A SUN

902
00:39:06,566 --> 00:39:08,400
AND GAS GIANTS FURTHER OUT.

903
00:39:08,400 --> 00:39:10,366
AND THAT WAS THE MODEL
I WAS TAUGHT IN GRADUATE SCHOOL.

904
00:39:10,366 --> 00:39:11,533
NAH, GONE.

905
00:39:11,533 --> 00:39:14,500
BECAUSE WE FOUND
THAT GAS GIANTS CAN FORM

906
00:39:14,500 --> 00:39:18,300
VERY CLOSE TO THEIR PARENT STAR
AND MIGRATE OUTWARD.

907
00:39:18,300 --> 00:39:21,733
PLANETS CAN FORM IN WAYS
THAT WE DIDN'T EXPECT.

908
00:39:21,733 --> 00:39:24,033
AND THAT, TO ME,
IS THE TRUE MAGIC

909
00:39:24,033 --> 00:39:25,900
OF SOMETHING LIKE KEPLER.

910
00:39:25,900 --> 00:39:28,266
IT'S THE TRUE MAGIC OF WHAT
WE'RE GOING TO BE ABLE TO DO

911
00:39:28,266 --> 00:39:29,833
WITH JWST.

912
00:39:29,833 --> 00:39:31,133
WE'RE GOING TO FIND THOSE--

913
00:39:31,133 --> 00:39:34,366
ACTUALLY DONALD RUMSFELD'S
UNKNOWN UNKNOWNS.

914
00:39:34,366 --> 00:39:37,100
WE'RE GOING TO FIND THE THINGS
THAT WE ACTUALLY DIDN'T EXPECT,

915
00:39:37,100 --> 00:39:39,766
BECAUSE THAT'S WHERE YOU REALLY
PUSH SCIENCE FORWARD.

916
00:39:39,766 --> 00:39:44,300
WE HAVE WHOLE NEW MODELS NOW OF
HOW WE THINK SOLAR SYSTEMS FORM.

917
00:39:44,300 --> 00:39:47,233
AND I ARGUE WE'RE PROBABLY
EVEN NOW ONLY SEEING

918
00:39:47,233 --> 00:39:49,033
ONE SMALL
PART OF THE PROBLEM.

919
00:39:49,033 --> 00:39:51,133
AS WE DEVELOP BETTER
AND BETTER TELESCOPES,

920
00:39:51,133 --> 00:39:55,633
LOOK WITH HIGHER RESOLUTION
INTO OTHER SOLAR SYSTEMS,

921
00:39:55,633 --> 00:39:59,800
WE'RE GOING TO LEARN SO MUCH
MORE AND REFINE THOSE MODELS.

922
00:39:59,800 --> 00:40:03,333
AND I'M REALLY EXCITED
FOR 2018,

923
00:40:03,333 --> 00:40:06,266
WHEN WE LAUNCH
THE JAMES WEBB SPACE TELESCOPE

924
00:40:06,266 --> 00:40:08,866
AND WE HAVE THE ABILITY
NOT JUST TO DETECT,

925
00:40:08,866 --> 00:40:12,733
OKAY, HERE'S A NEW PLANET,
HERE'S ITS LIKELY MASS,

926
00:40:12,733 --> 00:40:14,566
HERE'S ITS LIKELY ORBIT
AROUND A STAR.

927
00:40:14,566 --> 00:40:16,333
BUT WE'RE ACTUALLY
GOING TO BE ABLE

928
00:40:16,333 --> 00:40:18,400
TO START LOOKING AT
THE ATMOSPHERES OF THOSE PLANETS

929
00:40:18,400 --> 00:40:21,400
AND SAYING, "WHAT ARE THOSE
ATMOSPHERES ACTUALLY MADE OF?"

930
00:40:21,400 --> 00:40:25,566
AND INTO THE FUTURE,
AS WE'RE ABLE TO DEVELOP

931
00:40:25,566 --> 00:40:29,266
LARGER AND LARGER APERTURE
TELESCOPES,

932
00:40:29,266 --> 00:40:31,100
TO ACTUALLY BE ABLE TO SAY,

933
00:40:31,100 --> 00:40:33,766
"OKAY, HOW DO THOSE ATMOSPHERES
CHANGE OVER TIME?"

934
00:40:33,766 --> 00:40:36,533
AND, ULTIMATELY, CAN WE IMAGE
ONE OF THESE PLANETS

935
00:40:36,533 --> 00:40:40,433
AROUND ANOTHER STAR TO TRY
TO FIND THAT HABITABLE WORLD

936
00:40:40,433 --> 00:40:41,933
AROUND ANOTHER STAR?

937
00:40:41,933 --> 00:40:43,333
GETTING BACK
TO THAT QUESTION,

938
00:40:43,333 --> 00:40:45,333
NOT ONLY ARE WE ALONE
IN OUR OWN SOLAR SYSTEM,

939
00:40:45,333 --> 00:40:49,533
BUT ARE WE ALONE IN OUR GALAXY,
IN OUR UNIVERSE?

940
00:40:49,533 --> 00:40:51,100
REALLY CRITICAL QUESTIONS.

941
00:40:51,100 --> 00:40:53,400
AND, AGAIN, HIGHLIGHTS
THE IMPORTANCE TO ME

942
00:40:53,400 --> 00:40:54,666
OF REALLY NAILING DOWN
THIS QUESTION

943
00:40:54,666 --> 00:40:56,200
IN OUR OWN SOLAR SYSTEM.

944
00:40:56,200 --> 00:40:59,366
WE'D LIKE TO USE OUR OWN SOLAR

SYSTEM TO GET READY, TO ME,

945
00:40:59,366 --> 00:41:03,766
AS WE, IN THE NEXT 20 YEARS,
REALLY TURN THIS STUDY

946
00:41:03,766 --> 00:41:07,233
OF EXTRASOLAR PLANETS INTO WHAT
IS REALLY A NEW SCIENCE

947
00:41:07,233 --> 00:41:08,766
INTO A MAJOR
FIELD OF SCIENCE.

948
00:41:08,766 --> 00:41:12,533
INCREDIBLY EXCITING TIME
TO BE IN THIS FIELD.

949
00:41:12,533 --> 00:41:15,200
EVERYTHING IS CHANGING.

950
00:41:15,200 --> 00:41:17,666
YOU KNOW,
AT NASA WE INNOVATE,

951
00:41:17,666 --> 00:41:19,666
DOING THINGS LIKE BUILDING
THESE GIANT MIRRORS

952
00:41:19,666 --> 00:41:22,833
THAT ARE GOING ONTO THE HUBBLE--
THE JAMES WEBB SPACE TELESCOPE.

953
00:41:22,833 --> 00:41:24,966
AND FOR YOU GUYS
IN THE AUDIENCE,

954
00:41:24,966 --> 00:41:28,200
THERE'S A VIDEO ONLINE THAT
SHOWS HOW JAMES WEBB IS GOING--

955
00:41:28,200 --> 00:41:33,566
IT'S WAY TOO BIG TO FIT WITH
THOSE MIRRORS ALL SPREAD OUT.

956
00:41:33,566 --> 00:41:35,700
AND SO WHEN IT GETS LAUNCHED,

957
00:41:35,700 --> 00:41:40,700
EVERYTHING IS ALL FOLDED UP
TO FIT INSIDE THE SHROUD.

958
00:41:40,700 --> 00:41:43,933
SO AFTER IT LAUNCHES,
THE WHOLE THING HAS TO DEPLOY.

959
00:41:43,933 --> 00:41:45,900
AS SOMEBODY SAID,
I THINK IT'S--

960
00:41:45,900 --> 00:41:49,133
THEY SAID IT WAS THEIR, LIKE,
EIGHT DAYS OF TERROR

961
00:41:49,133 --> 00:41:51,566
AS OPPOSED TO THAT
SEVEN MINUTES OF TERROR GOING--

962
00:41:51,566 --> 00:41:53,433
LANDING ON THE SURFACE
OF MARS.

963
00:41:53,433 --> 00:41:55,800
ANYWAY, AMAZING
TECHNOLOGICAL FEAT.

964
00:41:55,800 --> 00:41:58,666
REALLY EXCITING. STAY TUNED
FOR 2018 AND JAMES WEBB.

965
00:41:58,666 --> 00:42:01,700
AND WATCH THAT VIDEO
ON THE WEB.

966
00:42:01,700 --> 00:42:03,666
YOU KNOW, AT NASA
WE'RE ABLE TO EXPLORE.

967
00:42:03,666 --> 00:42:06,200
WE HAVE EXPLORERS
RIGHT HERE AT AMES.

968
00:42:06,200 --> 00:42:09,033
AGAIN, MY FRIEND NAT,
WHO GETS OUT IN THE FIELD.

969
00:42:09,033 --> 00:42:10,866
AT NASA, WE GET OUT
IN THE FIELD.

970
00:42:10,866 --> 00:42:13,700
WE DO EXPERIMENTS.
WE STUDY.

971
00:42:13,700 --> 00:42:15,233
WE'RE UP IN THE ARCTIC.

972
00:42:15,233 --> 00:42:17,266
WE'RE DOWN IN CHILE
IN THE MOUNTAINS.

973
00:42:17,266 --> 00:42:20,200
WE'RE ALL OVER THIS PLANET
TRYING TO BETTER UNDERSTAND

974
00:42:20,200 --> 00:42:21,866
HOW OUR OWN PLANET
IS CHANGING,

975

00:42:21,866 --> 00:42:24,833
AND THE IMPLICATIONS OF THAT
FOR OTHER WORLDS,

976
00:42:24,833 --> 00:42:27,233
LIKE MARS, LIKE TITAN,
LIKE VENUS.

977
00:42:27,233 --> 00:42:29,500
WE MAKE DISCOVERIES
EVERY DAY,

978
00:42:29,500 --> 00:42:31,133
THE SCIENTIST HERE AT AMES.

979
00:42:31,133 --> 00:42:33,633
THE SCIENTISTS THAT WE HAVE
ACROSS THE AGENCY

980
00:42:33,633 --> 00:42:36,200
ARE USING INFORMATION,
WHETHER IT'S COMING

981
00:42:36,200 --> 00:42:39,666
FROM A SPACECRAFT OR UP ON THE
INTERNATIONAL SPACE STATION,

982
00:42:39,666 --> 00:42:42,900
TO MAKE NEW DISCOVERIES,
REALLY PUSH SCIENCE BACK.

983
00:42:42,900 --> 00:42:45,533
AND HOPEFULLY,
IN DOING ALL OF THESE THINGS,

984
00:42:45,533 --> 00:42:49,000
IN INNOVATING, IN CREATING
THINGS LIKE JAMES WEBB,

985
00:42:49,000 --> 00:42:51,000

IN EXPLORING, IN DISCOVERING,

986
00:42:51,000 --> 00:42:53,733
WE'RE ACTUALLY INSPIRING
THE NEXT GENERATION

987
00:42:53,733 --> 00:42:55,266
OF SPACE EXPLORERS.

988
00:42:55,266 --> 00:42:58,000
AND, AGAIN, I HOPE THAT MANY
OF YOU WHO ARE HERE

989
00:42:58,000 --> 00:43:01,366
AS INTERNS THIS SUMMER
CAN JOIN US IN THE FUTURE

990
00:43:01,366 --> 00:43:03,233
AND HELP US
ON THAT ROAD TO MARS.

991
00:43:03,233 --> 00:43:04,533
THANK YOU.

992
00:43:04,533 --> 00:43:06,533
[applause]

993
00:43:10,433 --> 00:43:13,600
AND I ACTUALLY PREFER ANSWERING
QUESTIONS TO TALKING, SO...

994
00:43:13,600 --> 00:43:15,733
[laughs]
THANK YOU.

995
00:43:15,733 --> 00:43:17,833
- THANK YOU. SO WE HAVE TIME
FOR A FEW QUESTIONS.

996

00:43:17,833 --> 00:43:21,566
AS USUAL, PLEASE RAISE YOUR HAND
IF YOU HAVE A QUESTION.

997
00:43:21,566 --> 00:43:22,866
WAIT FOR THE MICROPHONE,

998
00:43:22,866 --> 00:43:25,000
AND STAND UP WHEN YOU ASK
YOUR QUESTION.

999
00:43:29,866 --> 00:43:32,466
- THERE'S ABOUT A MILLION
NEAR-EARTH OBJECTS

1000
00:43:32,466 --> 00:43:34,100
BIG ENOUGH TO DESTROY A CITY,

1001
00:43:34,100 --> 00:43:36,466
AND WE DON'T KNOW
WHERE 99% OF THEM ARE,

1002
00:43:36,466 --> 00:43:38,300
AND ONE HIT US LAST YEAR.

1003
00:43:38,300 --> 00:43:39,966
YOU DIDN'T MENTION IT.
COULD YOU TALK A LITTLE BIT

1004
00:43:39,966 --> 00:43:41,800
ABOUT WHAT NASA'S DOING
TO UNDERSTAND

1005
00:43:41,800 --> 00:43:44,500
AND MITIGATE THAT THREAT?

1006
00:43:44,500 --> 00:43:46,400
- THAT'S A GREAT QUESTION.

1007

00:43:46,400 --> 00:43:49,000
AND OBVIOUSLY,
YOU KNOW, AGAIN,

1008
00:43:49,000 --> 00:43:50,566
BACK WHEN I WAS IN SCHOOL

1009
00:43:50,566 --> 00:43:52,066
AND WE LEARNED ABOUT
THE TUNGUSKA EVENT,

1010
00:43:52,066 --> 00:43:55,666
WHERE THIS EVENT--YOU KNOW,
THIS METEOR CAME IN OVER SIBERIA

1011
00:43:55,666 --> 00:43:58,200
AND EXPLODED,
AND KNOCKED DOWN, YOU KNOW,

1012
00:43:58,200 --> 00:44:01,900
HUNDREDS AND HUNDREDS OF ACRES
OF PINE TREES IN SIBERIA.

1013
00:44:01,900 --> 00:44:04,233
AND I THOUGHT, "WOW,
THIS IS NEVER GOING TO HAPPEN

1014
00:44:04,233 --> 00:44:05,633
IN MY LIFETIME."

1015
00:44:05,633 --> 00:44:07,566
AND THEN POOR SIBERIA,
YOU KNOW, WITH CHELYABINSK,

1016
00:44:07,566 --> 00:44:09,233
GETS HIT AGAIN LAST YEAR.

1017
00:44:09,233 --> 00:44:11,300
AND LUCKILY, OBVIOUSLY,
NO LOSS OF LIFE

1018
00:44:11,300 --> 00:44:13,766
BUT SOME AMOUNT OF DAMAGE.

1019
00:44:13,766 --> 00:44:16,333
ASTEROIDS ARE A HAZARD.

1020
00:44:16,333 --> 00:44:19,466
COMETS AND ASTEROIDS
BOTH ARE A HAZARD TO PLANETS.

1021
00:44:19,466 --> 00:44:21,166
IT'S WHAT--YOU KNOW,
THAT'S WHY THE MOON

1022
00:44:21,166 --> 00:44:22,566
IS SUCH A GREAT PLACE
TO STUDY,

1023
00:44:22,566 --> 00:44:25,000
BECAUSE IT GIVES US
THAT CRATERING HISTORY

1024
00:44:25,000 --> 00:44:28,200
THAT EROSION HAS WIPED AWAY
FROM THE EARTH.

1025
00:44:28,200 --> 00:44:30,700
AT NASA RIGHT NOW,
OUR MAJOR EFFORT

1026
00:44:30,700 --> 00:44:34,633
IS IN TRYING TO CHARACTERIZE
THAT POPULATION

1027
00:44:34,633 --> 00:44:39,600
OF EARTH-CROSSING OBJECTS ABOVE
ABOUT 2 KILOMETERS IN SIZE.

1028

00:44:39,600 --> 00:44:42,766
SO WE REACTIVATED
THE "WISE" SPACECRAFT,

1029
00:44:42,766 --> 00:44:44,866
NOW CALLED "NEOWISE."

1030
00:44:44,866 --> 00:44:48,966
THERE'S A HUGE EARTH-BASED
PROGRAM OF OBSERVATION.

1031
00:44:48,966 --> 00:44:52,233
AND IT'S REALLY TO TRY TO GET--
CHARACTERIZE THAT POPULATION

1032
00:44:52,233 --> 00:44:55,366
OF EARTH-CROSSERS DOWN
TO A SMALLER AND SMALLER SIZE.

1033
00:44:55,366 --> 00:44:58,633
OBVIOUSLY WHEN YOU ARE LOOKING
FOR THINGS THAT SMALL...

1034
00:44:58,633 --> 00:45:01,566
AND IN GENERAL YOU'RE TRYING TO
FIND THEM WHEN THEY'RE FAR AWAY,

1035
00:45:01,566 --> 00:45:02,933
SO THEY'RE VERY FAINT.

1036
00:45:02,933 --> 00:45:04,500
SO IT'S A CHALLENGE,
AND IT'S GOING TO TAKE US

1037
00:45:04,500 --> 00:45:07,666
A LITTLE LONGER TO BUILD UP THE
FULL DATABASE THAN WE HAD HOPED.

1038
00:45:07,666 --> 00:45:10,433
BUT WE'RE CONTINUING TO DO IT,

BECAUSE--

1039
00:45:10,433 --> 00:45:13,366
BECAUSE THERE'S NO QUESTION
THAT THINGS HAVE HIT US BEFORE,

1040
00:45:13,366 --> 00:45:15,433
AND THEY WILL HIT US AGAIN.

1041
00:45:17,633 --> 00:45:19,733
- SO, WHAT WOULD BE SOME
OF THE ETHICAL

1042
00:45:19,733 --> 00:45:22,500
AND SCIENTIFIC
CONSEQUENCES

1043
00:45:22,500 --> 00:45:24,100
IF WE FOUND LIFE
ON ANOTHER PLANET?

1044
00:45:24,100 --> 00:45:26,700
LIKE, FOR EXAMPLE,
FOR COLONIZATION.

1045
00:45:26,700 --> 00:45:28,733
- WELL, YOU KNOW,
ONE OF THE FIRST THINGS

1046
00:45:28,733 --> 00:45:31,800
THAT I THINK IT'S IMPORTANT
TO STEP BACK AND REMEMBER,

1047
00:45:31,800 --> 00:45:36,166
IS ONE OF THE CHIEF THINGS
WE DO AT NASA RIGHT NOW

1048
00:45:36,166 --> 00:45:38,400
IS TO TRY TO MAKE SURE
THAT WHEN WE GO OUT

1049
00:45:38,400 --> 00:45:40,033
AND LOOK FOR LIFE
ON ANOTHER PLANET

1050
00:45:40,033 --> 00:45:43,966
THAT WE DON'T REDISCOVER LIFE
THAT WE BROUGHT ALONG WITH US.

1051
00:45:43,966 --> 00:45:47,900
AND SO PLANETARY PROTECTION
IS A HUGE ISSUE.

1052
00:45:47,900 --> 00:45:50,266
SO ONE OF THE THINGS THAT WE DO
REALLY RIGOROUSLY

1053
00:45:50,266 --> 00:45:52,433
IS WHEN WE SEND SPACECRAFT...

1054
00:45:52,433 --> 00:45:55,566
FOR EXAMPLE,
ANYTHING THAT GOES TO MARS

1055
00:45:55,566 --> 00:45:58,566
HAS TO GO THROUGH
REALLY RIGOROUS PROCESSES

1056
00:45:58,566 --> 00:46:01,800
TO MAKE SURE IT'S BIOLOGICALLY
AS CLEAN AS WE CAN MAKE IT.

1057
00:46:01,800 --> 00:46:04,700
THE SAME GOES, FOR EXAMPLE,
WITH THE "CASSINI" SPACECRAFT,

1058
00:46:04,700 --> 00:46:07,266
HAS TO BE KEPT AWAY
FROM ENCELADUS.

1059
00:46:07,266 --> 00:46:09,933
AND ANYTHING THAT GOES
TO THE JUPITER SYSTEM

1060
00:46:09,933 --> 00:46:11,400
HAS TO BE KEPT AWAY
FROM ACTUALLY

1061
00:46:11,400 --> 00:46:13,333
LIKE CRASHING INTO EUROPA.

1062
00:46:13,333 --> 00:46:14,933
SO ONE OF THE FIRST THINGS
THAT WE DO

1063
00:46:14,933 --> 00:46:17,500
IS TRY TO MAKE SURE
THAT ANY LIFE WE FOUND,

1064
00:46:17,500 --> 00:46:19,700
WE DIDN'T BRING IT WITH US.

1065
00:46:19,700 --> 00:46:23,300
SO WE TRY TO MAKE IT CLEAR
WHEN WE EVENTUALLY DO FIND IT.

1066
00:46:23,300 --> 00:46:26,033
YOU KNOW,
I THINK ON ONE LEVEL,

1067
00:46:26,033 --> 00:46:28,633
OBVIOUSLY ONE OF THE THINGS
YOU'RE REALLY GONNA WANT TO DO

1068
00:46:28,633 --> 00:46:31,233
IS TO REALLY UNDERSTAND
HOW SIMILAR OR DISSIMILAR

1069
00:46:31,233 --> 00:46:34,000

IS ANY LIFE YOU FIND
TO LIFE HERE ON EARTH.

1070
00:46:34,000 --> 00:46:35,933
YOU KNOW, DOES IT HAVE DNA
AND RNA?

1071
00:46:35,933 --> 00:46:38,100
WHAT ARE THE CHARACTERISTICS
OF IT, HOW DIFFERENT IS IT?

1072
00:46:38,100 --> 00:46:40,600
DOES IT USE SUGARS AND PROTEINS
IN THE SAME WAY?

1073
00:46:40,600 --> 00:46:44,133
SO HUGE, JUST FUNDAMENTAL
BIOLOGICAL QUESTIONS.

1074
00:46:44,133 --> 00:46:49,133
WE HAVE ONE EXAMPLE THAT WE HAVE
STUDIED PRETTY DARN WELL,

1075
00:46:49,133 --> 00:46:50,866
AND WE DON'T HAVE
ANY OTHER EXAMPLES.

1076
00:46:50,866 --> 00:46:55,866
AND SO THE SCIENTIFIC ADVANCES
THAT WE WILL MAKE

1077
00:46:55,866 --> 00:46:59,600
WHEN WE FIND LIFE ON ANOTHER
WORLD I THINK IS EXCITING.

1078
00:46:59,600 --> 00:47:01,933
AND, FRANKLY, I DO THINK IT'S
GOING TO HAPPEN IN OUR LIFETIME,

1079
00:47:01,933 --> 00:47:05,066

BECAUSE I THINK BOTH EUROPA
AND MARS ARE GREAT CANDIDATES.

1080
00:47:05,066 --> 00:47:06,800
SO I'M PRETTY EXCITED
ABOUT IT.

1081
00:47:06,800 --> 00:47:09,866
YOU KNOW,
ETHICALLY AND PHILOSOPHICALLY,

1082
00:47:09,866 --> 00:47:12,700
YOU KNOW, YOU CAN SAY IT'S JUST
GOING TO BLOW EVERYBODY'S MIND.

1083
00:47:12,700 --> 00:47:15,066
YOU KNOW, THAT'S NOT A GREAT
ANSWER, BUT I THINK IT'S TRUE.

1084
00:47:18,800 --> 00:47:21,633
- I THINK THE DISCUSSION
OF CLIMATE CHANGE

1085
00:47:21,633 --> 00:47:23,400
IS EXTREMELY IMPORTANT.

1086
00:47:23,400 --> 00:47:28,033
AND IT SEEMS TO ME THAT NASA
SHOULD BE REALLY VERY ACTIVE,

1087
00:47:28,033 --> 00:47:29,766
NOT ONLY IN PROVIDING
EXPERIMENTS

1088
00:47:29,766 --> 00:47:32,433
TO TRY TO UNDERSTAND
THE SPACE STATION AND SO ON,

1089
00:47:32,433 --> 00:47:37,066
BUT IN THE EDUCATIONAL PROGRAM

THAT BRINGS THE CONCERNS

1090
00:47:37,066 --> 00:47:39,133
AND INTERESTS IN SCIENCE
TO THE PUBLIC,

1091
00:47:39,133 --> 00:47:40,766
AND PARTICULARLY
TO THE YOUNG.

1092
00:47:40,766 --> 00:47:42,933
IS THERE AN EDUCATIONAL PROGRAM,

1093
00:47:42,933 --> 00:47:46,200
NOW THAT THE EDUCATIONAL PROGRAM
HAS BEEN, TO SOME EXTENT,

1094
00:47:46,200 --> 00:47:49,666
DIVORCED FROM NASA,

1095
00:47:49,666 --> 00:47:53,000
THAT ALLOWS NASA TO CONTINUE
TO HELP YOUNG PEOPLE

1096
00:47:53,000 --> 00:47:55,566
LEARN ABOUT CLIMATE CHANGE?

1097
00:47:55,566 --> 00:47:57,033
- THE SCIENCE--BILL, I THINK
YOU'RE ABSOLUTELY RIGHT.

1098
00:47:57,033 --> 00:47:59,233
IT'S SUCH A--YOU KNOW...

1099
00:47:59,233 --> 00:48:00,966
PUTTING EVERYTHING ASIDE,
YOU KNOW,

1100
00:48:00,966 --> 00:48:03,700

CLIMATE CHANGE
IS THE CHALLENGE.

1101
00:48:03,700 --> 00:48:06,466
YOU KNOW, WE'VE--IT'S GOT
TO BE ADDRESSED.

1102
00:48:06,466 --> 00:48:10,066
AND THAT EDUCATION BIT
IS A GOOD PART OF IT.

1103
00:48:10,066 --> 00:48:12,133
THOUGH I WILL SAY MOST AUDIENCES
YOU GO OUT TO,

1104
00:48:12,133 --> 00:48:15,766
IF THEY'RE UNDER ABOUT 14,
THEY'RE PRETTY MUCH IN LINE.

1105
00:48:15,766 --> 00:48:19,833
IF THEY'RE ABOVE 14,
THAT'S WHERE IT GETS MORE DODGY.

1106
00:48:19,833 --> 00:48:24,333
BUT I THINK THOSE--THERE IS
STILL A LOT OF EDUCATION WORK

1107
00:48:24,333 --> 00:48:26,066
THAT'S GOING ON THROUGH
THE SCIENCE MISSION DIRECTORATE

1108
00:48:26,066 --> 00:48:27,500
AND THEN THROUGH
THE EARTH SCIENCE.

1109
00:48:27,500 --> 00:48:29,633
AND CLIMATE CHANGE IS A CRITICAL
PART OF ALL OF THAT.

1110
00:48:29,633 --> 00:48:32,800

AND I'VE TAKEN PART
IN TWO RECENT EVENTS,

1111
00:48:32,800 --> 00:48:34,900
THE CLIMATE DATA INITIATIVE

1112
00:48:34,900 --> 00:48:36,633
THAT WAS ANNOUNCED
AT THE WHITE HOUSE,

1113
00:48:36,633 --> 00:48:39,300
AND THEN THE--WHEN THE--

1114
00:48:39,300 --> 00:48:42,700
THE NATIONAL CLIMATE ASSESSMENT
CAME OUT.

1115
00:48:42,700 --> 00:48:45,133
NASA'S BEEN PLAYING
A HUGE ROLE IN THAT.

1116
00:48:45,133 --> 00:48:47,166
AND THAT'S NOT SO MUCH AIMED
AT EDUCATION

1117
00:48:47,166 --> 00:48:49,633
AS IT'S AIMED IN HOW CAN WE TAKE
ALL OF THIS DATA

1118
00:48:49,633 --> 00:48:52,666
THAT WE COLLECT AT NASA
THAT SCIENTISTS ARE USING

1119
00:48:52,666 --> 00:48:55,233
TO ANALYZE CLIMATE CHANGE IN
WAYS THAT ARE REALLY IMPORTANT.

1120
00:48:55,233 --> 00:48:56,666
I DON'T WANT
TO MAKE LIGHT OF THAT.

1121
00:48:56,666 --> 00:48:59,266
BUT HOW CAN WE TAKE THAT DATA
AND ACTUALLY MAKE IT

1122
00:48:59,266 --> 00:49:01,133
MORE ACCESSIBLE TO, SAY,

1123
00:49:01,133 --> 00:49:04,066
A CITY MANAGER
IN COASTAL NORTH CAROLINA?

1124
00:49:04,066 --> 00:49:06,766
HOW CAN THEY UNDERSTAND,
YOU KNOW,

1125
00:49:06,766 --> 00:49:08,733
BASED ON CURRENT MODELS,
WHAT ARE THE CHANCES

1126
00:49:08,733 --> 00:49:12,100
OF COASTAL INUNDATION,
COASTAL FLOODING IN THIS AREA

1127
00:49:12,100 --> 00:49:13,466
OVER THE NEXT TEN YEARS?

1128
00:49:13,466 --> 00:49:16,000
HOW CAN WE MAKE
THESE PREDICTIONS AND THESE DATA

1129
00:49:16,000 --> 00:49:18,133
THAT WE INCREASINGLY NOW HAVE
ON A REGIONAL LEVEL

1130
00:49:18,133 --> 00:49:21,033
AS CAME OUT IN THE NATIONAL
CLIMATE ASSESSMENT.

1131

00:49:21,033 --> 00:49:24,800
HOW CAN WE MAKE THAT DATA
AVAILABLE TO DECISION-MAKERS?

1132
00:49:24,800 --> 00:49:28,866
MAYBE NOT ON THE NATIONAL LEVEL
WHERE THERE'S SO MUCH NOISE,

1133
00:49:28,866 --> 00:49:31,166
BUT DOWN ON
A LOCAL LEVEL WHERE,

1134
00:49:31,166 --> 00:49:33,000
FOR EXAMPLE,
IN NORFOLK VIRGINIA,

1135
00:49:33,000 --> 00:49:34,866
YOU KNOW,
IT'S FLOODING ALREADY.

1136
00:49:34,866 --> 00:49:36,966
THERE'S SUBSIDENCE COMBINED
WITH SEA LEVEL RISE,

1137
00:49:36,966 --> 00:49:40,066
AND THERE'S A HUGE AMOUNT
OF MONEY BEING SPENT

1138
00:49:40,066 --> 00:49:43,500
TO TRY TO FIX IT,
AND IT'S NOT GOING TO GET FIXED.

1139
00:49:43,500 --> 00:49:46,500
AND SO I THINK TRYING TO MAKE
SURE OUR DATA SETS

1140
00:49:46,500 --> 00:49:48,500
ARE READILY AVAILABLE

1141
00:49:48,500 --> 00:49:50,933

TO THOSE
"DECISION-MAKERS" OUT THERE

1142
00:49:50,933 --> 00:49:54,466
IS AS CRITICAL AS THE OUTREACH
BIT THAT WE DO,

1143
00:49:54,466 --> 00:49:55,900
AND IT'S INCREDIBLY
IMPORTANT.

1144
00:49:55,900 --> 00:49:57,600
I WILL SAY IT'S A SOURCE
OF FRUSTRATION

1145
00:49:57,600 --> 00:49:59,333
TO MANY PEOPLE IN THE AGENCY

1146
00:49:59,333 --> 00:50:02,600
THAT IF WE GO OUT AND TALK ABOUT
CLIMATE CHANGE AND MARS,

1147
00:50:02,600 --> 00:50:05,766
THE PRESS QUOTES US ON MARS AND
NOT SO MUCH ON CLIMATE CHANGE.

1148
00:50:05,766 --> 00:50:07,533
AND I DO THINK THERE'S A LOT
OF PEOPLE IN THE AGENCY

1149
00:50:07,533 --> 00:50:09,166
TRYING TO TALK ABOUT
CLIMATE CHANGE,

1150
00:50:09,166 --> 00:50:10,500
BUT THE MESSAGE
DOESN'T ALWAYS--

1151
00:50:10,500 --> 00:50:13,133
DOESN'T ALWAYS MAKE IT

TO THE GENERAL PUBLIC.

1152
00:50:13,133 --> 00:50:14,933
SO I WOULD URGE ALL OF YOU
WHO GO OUT,

1153
00:50:14,933 --> 00:50:19,333
I SHOW THAT TEMPERATURE VIDEO,
WHICH IS AVAILABLE THROUGH THE--

1154
00:50:19,333 --> 00:50:21,100
THAT'S THE GODDARD
INSTITUTE OF SPACE STUDIES.

1155
00:50:21,100 --> 00:50:24,000
BUT, YOU KNOW, YOU JUST GOOGLE
"CLIMATE CHANGE"

1156
00:50:24,000 --> 00:50:26,166
OR "TEMPERATURE CHANGE."

1157
00:50:26,166 --> 00:50:30,100
EVERY TIME I SHOW THAT VIDEO
TO THE GENERAL PUBLIC--

1158
00:50:30,100 --> 00:50:32,800
YOU KNOW, IN GENERAL,
PEOPLE GASP.

1159
00:50:32,800 --> 00:50:34,500
YOU KNOW,
THEY JUST DON'T--

1160
00:50:34,500 --> 00:50:36,166
THERE ARE SO MANY PEOPLE
IN THE GENERAL PUBLIC

1161
00:50:36,166 --> 00:50:38,333
WHO JUST DON'T UNDERSTAND
THAT WHEN WE TALK ABOUT THE FACT

1162
00:50:38,333 --> 00:50:41,033
THAT THE PLANET HAS WARMED
OVER THE LAST 20 YEARS,

1163
00:50:41,033 --> 00:50:42,233
THEY THINK WE'RE MAKING IT UP.

1164
00:50:42,233 --> 00:50:43,666
AND WHEN YOU SHOW THEM THAT,
THEY SAY,

1165
00:50:43,666 --> 00:50:46,233
"WOW, THAT'S DATA.
I GET IT."

1166
00:50:46,233 --> 00:50:48,400
AND I CAN'T TELL YOU--I'VE HAD
FLOODS OF PEOPLE COME UP TO ME.

1167
00:50:48,400 --> 00:50:50,400
YOU KNOW, I'VE GIVEN--TALKED TO,
LIKE, A LOCAL WOMEN'S GROUP.

1168
00:50:50,400 --> 00:50:52,200
AND PEOPLE WILL COME UP TO ME
AND SAY,

1169
00:50:52,200 --> 00:50:54,466
"WOW, THAT'S KIND OF SCARY."

1170
00:50:54,466 --> 00:50:56,466
AND YOU'RE LIKE,
"YEAH, IT IS KIND OF SCARY."

1171
00:51:00,833 --> 00:51:04,566
- YOU TALKED ABOUT
DATING ROCKS ON MARS.

1172

00:51:04,566 --> 00:51:05,966
- [laughs]

1173
00:51:05,966 --> 00:51:07,666
THAT SOUNDS KIND OF ODD,
BUT YEAH.

1174
00:51:07,666 --> 00:51:10,400
- I WAS WONDERING
HOW YOU GO ABOUT DOING THAT,

1175
00:51:10,400 --> 00:51:13,366
BECAUSE IF YOU DO IT
WITH ISOTOPES,

1176
00:51:13,366 --> 00:51:18,366
I KNOW ON EARTH YOU HAVE TO USE
SOME PRETTY COMPLEX TABLES

1177
00:51:18,366 --> 00:51:21,433
THAT HAVE BEEN DEVELOPED
OVER THE YEARS

1178
00:51:21,433 --> 00:51:24,900
DETERMINING WHAT AMOUNTS
OF EACH ISOTOPE WERE PRESENT.

1179
00:51:24,900 --> 00:51:27,566
HOW DO YOU GO ABOUT DOING
SOMETHING LIKE THAT ON MARS?

1180
00:51:27,566 --> 00:51:29,566
- IT WASN'T MY RESEARCH,

1181
00:51:29,566 --> 00:51:31,233
SO I CAN'T EXACTLY
QUOTE IT TO YOU.

1182
00:51:31,233 --> 00:51:32,733
I'M PRETTY SURE THEY USED--

1183
00:51:32,733 --> 00:51:34,200
SOMEBODY CAN SHOUT OUT
AND CORRECT ME IF I'M WRONG--

1184
00:51:34,200 --> 00:51:36,500
I'M PRETTY SURE THEY USED
POTASSIUM ARGON,

1185
00:51:36,500 --> 00:51:38,366
THOUGH THEY MIGHT HAVE USED
RUBIDIUM-STRONTIUM

1186
00:51:38,366 --> 00:51:42,000
FOR ONE OF THE OTHER--THEY DID
A COUPLE DIFFERENT DATES.

1187
00:51:42,000 --> 00:51:44,566
BUT THEY WERE ABLE
TO GET--

1188
00:51:44,566 --> 00:51:46,766
AGAIN, YOU HAVE TO MAKE
ASSUMPTIONS.

1189
00:51:46,766 --> 00:51:48,700
SO IT'S NOT--IT'S NOT LIKE
THERE AREN'T ERROR BARS.

1190
00:51:48,700 --> 00:51:51,200
AND THE ERROR BARS ARE BECAUSE
OF WHAT YOU JUST SAID.

1191
00:51:51,200 --> 00:51:53,100
YOU HAVE TO MAKE ASSUMPTIONS
ABOUT THE ORIGINAL CONTENT

1192
00:51:53,100 --> 00:51:55,066
OF EACH OF THE RADIOACTIVE
MINERALS

1193
00:51:55,066 --> 00:51:57,600
TO BE ABLE TO DO THE--
TO DO IT.

1194
00:51:57,600 --> 00:52:00,800
BUT GIVEN THOSE ASSUMPTIONS,
WHICH MAKE YOUR ERROR BARS GO UP

1195
00:52:00,800 --> 00:52:02,800
AS OPPOSED TO THE MUCH SMALLER
ERROR BARS

1196
00:52:02,800 --> 00:52:04,366
WE HAVE HERE ON EARTH,

1197
00:52:04,366 --> 00:52:06,766
YOU STILL ARE ABLE TO GET
AN AGE DATE.

1198
00:52:06,766 --> 00:52:09,000
AND, AGAIN, WE'RE ABLE
TO KIND OF FIT IT IN

1199
00:52:09,000 --> 00:52:10,666
WITH EVERYTHING ELSE
WE KNOW ABOUT MARS

1200
00:52:10,666 --> 00:52:14,033
THAT ACTUALLY MAKES SENSE
GEOLOGICALLY.

1201
00:52:14,033 --> 00:52:16,733
BIGGER ERROR BARS
THAN WE WOULD LIKE,

1202
00:52:16,733 --> 00:52:18,800
BUT STILL AN ACTUAL
AGE DATE.

1203
00:52:18,800 --> 00:52:20,466
AND, AGAIN,
HUGELY POWERFUL,

1204
00:52:20,466 --> 00:52:22,233
NOW BE ABLE TO THINK
OF SENDING THOSE

1205
00:52:22,233 --> 00:52:23,633
LOTS OF PLACES ON MARS,

1206
00:52:23,633 --> 00:52:26,566
AGAIN, BEING ABLE TO GET
ROUGH AGE DATES ON VENUS,

1207
00:52:26,566 --> 00:52:27,866
WHICH WE WOULD LOVE TO KNOW.

1208
00:52:27,866 --> 00:52:29,666
THERE'S A HUGE DEBATE
ON THE SURFACE OF VENUS

1209
00:52:29,666 --> 00:52:33,366
OVER WHEN THE SURFACE--
WHEN MUCH OF THE SURFACE FORMED,

1210
00:52:33,366 --> 00:52:34,900
RELATIVE AGE
OF SURFACE UNITS.

1211
00:52:34,900 --> 00:52:36,366
AND VENUS IS A WHOLE
NOTHER STRUGGLE,

1212
00:52:36,366 --> 00:52:39,166
BECAUSE THE TEMPERATURES
ARE SO HIGH,

1213
00:52:39,166 --> 00:52:42,533

THE SYSTEMATICS MIGHT RESET
COMPLEX GEOCHEMISTRY STUFF.

1214
00:52:42,533 --> 00:52:45,100
BUT STILL, SOME OF THE ISSUES
THAT YOU TALK ABOUT--

1215
00:52:45,100 --> 00:52:47,433
STILL, GETTING
PRETTY CRUMMY AGES

1216
00:52:47,433 --> 00:52:49,366
IS A LOT BETTER
THAN WHAT WE HAVE NOW.

1217
00:52:49,366 --> 00:52:51,366
SO REALLY EXCITING
TO MOVE THE TECHNIQUE FORWARD

1218
00:52:51,366 --> 00:52:53,366
OFF THE PLANET.

1219
00:52:56,133 --> 00:52:59,766
- HI. YOU SPOKE A LOT ABOUT SOME
EXCITING PLANETARY MISSIONS

1220
00:52:59,766 --> 00:53:03,333
WITH A LOT FARTHER
TIME OUTLOOKS.

1221
00:53:03,333 --> 00:53:08,300
HOW DO YOU PLAN FOR FUNDING
THESE KINDS OF LONG-TERM,

1222
00:53:08,300 --> 00:53:10,733
REALLY EXCITING,
REALLY HARD-TO-DO MISSIONS

1223
00:53:10,733 --> 00:53:13,866
ACROSS SO MANY ADMINISTRATIONS

AND TIME FRAMES?

1224
00:53:13,866 --> 00:53:15,500
AND THEN IS THERE ANYTHING,
AS ENGINEERS,

1225
00:53:15,500 --> 00:53:17,800
THAT WE CAN DO TO HELP ENABLE
THESE KINDS OF MISSIONS

1226
00:53:17,800 --> 00:53:20,000
UNDER TIGHTER BUDGET
CONSTRAINTS?

1227
00:53:20,000 --> 00:53:21,433
- WELL, OBVIOUSLY
TO SOME EXTENT--

1228
00:53:21,433 --> 00:53:24,466
WE'RE A 30-YEAR AGENCY
THAT LIVES IN A TWO-YEAR TOWN.

1229
00:53:24,466 --> 00:53:26,200
AND, YOU KNOW, THAT--

1230
00:53:26,200 --> 00:53:29,033
THAT HAS ALWAYS BEEN
THE WAY IT IS.

1231
00:53:29,033 --> 00:53:33,533
AND SO WHAT IT--WHAT IT TAKES
IS A CONSISTENT STORY

1232
00:53:33,533 --> 00:53:35,466
THAT'S BROADLY ACCEPTABLE.

1233
00:53:35,466 --> 00:53:37,733
IF YOU THINK OF HOW DID WE GET
TO THE MOON,

1234
00:53:37,733 --> 00:53:39,966
WHICH TOOK AN ENORMOUS
AMOUNT OF RESOURCES,

1235
00:53:39,966 --> 00:53:42,866
WE HAD A CONSISTENT STORY
THAT WAS BROADLY ACCEPTED

1236
00:53:42,866 --> 00:53:45,533
BY THE GOVERNMENT
AS THE RIGHT THING TO DO.

1237
00:53:45,533 --> 00:53:49,066
AND SO THAT'S
A HARD THING TO DO, RIGHT,

1238
00:53:49,066 --> 00:53:50,966
TO GET IT BROADLY
ACCEPTABLE.

1239
00:53:50,966 --> 00:53:52,633
HOW WELL DOES THAT PLAY
IN WASHINGTON, RIGHT?

1240
00:53:52,633 --> 00:53:55,366
I MEAN,
SO TRYING TO OPERATE.

1241
00:53:55,366 --> 00:53:59,333
THE GOOD THING FOR NASA
IS WE ACTUALLY HAVE HAD,

1242
00:53:59,333 --> 00:54:02,533
FOR A LONG TIME,
HUGE BIPARTISAN SUPPORT.

1243
00:54:02,533 --> 00:54:03,766
I MEAN, I CAN'T TELL YOU.

1244

00:54:03,766 --> 00:54:05,066
WHEN I GO UP
ON CAPITOL HILL

1245
00:54:05,066 --> 00:54:07,300
AND CONGRESSMEN FIND OUT
I WORK FOR NASA,

1246
00:54:07,300 --> 00:54:10,033
THE FIRST THING
THEY NORMALLY SAY TO ME IS,

1247
00:54:10,033 --> 00:54:13,566
"I LOVE NASA.
I LOVE YOU GUYS."

1248
00:54:13,566 --> 00:54:16,000
AND I THINK
EVEN WHEN PEOPLE SAY,

1249
00:54:16,000 --> 00:54:17,966
"WELL, THE FEDERAL GOVERNMENT
IS SPENDING TOO MUCH MONEY,"

1250
00:54:17,966 --> 00:54:21,033
I THINK PEOPLE SAY, "WELL, OKAY,
WE NEED TO MAKE SURE

1251
00:54:21,033 --> 00:54:23,600
NASA HAS NOT UNLIMITED
RESOURCES,"

1252
00:54:23,600 --> 00:54:25,266
BUT THEY UNDERSTAND
THE BENEFIT.

1253
00:54:25,266 --> 00:54:28,133
I'M NOT HAVING TO SIT THERE
AND EXPLAIN, YOU KNOW,

1254

00:54:28,133 --> 00:54:29,666
IT'S AN INVESTMENT
IN THE ECONOMY,

1255
00:54:29,666 --> 00:54:31,666
HUGE SCIENTIFIC RETURN,
PUBLIC INSPIRATION.

1256
00:54:31,666 --> 00:54:33,700
THEY GET IT.

1257
00:54:33,700 --> 00:54:35,333
ON THE OTHER HAND,
THE FEDERAL GOVERNMENT

1258
00:54:35,333 --> 00:54:36,866
HAS A LIMITED
AMOUNT OF MONEY,

1259
00:54:36,866 --> 00:54:39,266
AND THERE'S A LOT OF PRESSURE
ON THAT LIMITED AMOUNT OF MONEY.

1260
00:54:39,266 --> 00:54:43,433
SO I THINK THE MORE AT NASA
THAT WE CAN GET OUT THERE

1261
00:54:43,433 --> 00:54:46,966
AND TELL OUR STORY,
THE MORE WE CAN CONVINCE

1262
00:54:46,966 --> 00:54:48,766
A VERY DISTRACTED PUBLIC,

1263
00:54:48,766 --> 00:54:51,133
WHO'S DISTRACTED BY LOTS
OF DIFFERENT INPUTS,

1264
00:54:51,133 --> 00:54:53,666
THAT WHAT WE'RE DOING

IS VALUABLE AND COOL.

1265
00:54:53,666 --> 00:54:55,600
AND THAT'S OBVIOUSLY
ON A LOT OF US

1266
00:54:55,600 --> 00:54:57,266
WHO DO IT
ON OUR OWN TIME.

1267
00:54:57,266 --> 00:55:00,300
BUT THE PUBLIC GENERALLY
REALLY APPRECIATES IT.

1268
00:55:00,300 --> 00:55:02,000
THEY LOVE HEARING ABOUT
WHAT WE DO.

1269
00:55:02,000 --> 00:55:05,366
SO THE FIRST THING YOU CAN DO
IS GET OUT THERE AND TALK.

1270
00:55:05,366 --> 00:55:07,333
AND I KNOW IT'S ON
YOUR OWN TIME,

1271
00:55:07,333 --> 00:55:08,500
AND THAT'S NOT ALWAYS GREAT.

1272
00:55:08,500 --> 00:55:09,866
BUT THE MORE
YOU GET OUT THERE

1273
00:55:09,866 --> 00:55:12,800
AND TALK ABOUT THE COOL STUFF
THAT WE'RE DOING,

1274
00:55:12,800 --> 00:55:15,033
THE BETTER OFF
WE'RE GOING TO BE.

1275
00:55:15,033 --> 00:55:17,733
AND THEN IT'S ON THE NASA
LEADERSHIP TO MAKE SURE

1276
00:55:17,733 --> 00:55:20,966
THAT WE HAVE A PLAN,
LIKE THE ROAD TO MARS,

1277
00:55:20,966 --> 00:55:22,766
WHERE WE CAN SAY
HERE'S WHAT WE'RE DOING,

1278
00:55:22,766 --> 00:55:24,933
HERE'S WHY, HERE'S HOW WE'RE
GOING TO DO IT.

1279
00:55:24,933 --> 00:55:29,400
AND HERE'S HOW NOT ONLY IS IT
SCIENTIFICALLY IMPORTANT,

1280
00:55:29,400 --> 00:55:32,900
IT'S LAYING OUT A TECHNOLOGICAL
CHALLENGE FOR THE NATION,

1281
00:55:32,900 --> 00:55:34,433
FOR THE INTERNATIONAL
COMMUNITY

1282
00:55:34,433 --> 00:55:37,266
THAT'S IMPORTANT FOR LONG-TERM
INVESTMENT AND SKILLS

1283
00:55:37,266 --> 00:55:40,266
THAT WE NEED AS A COUNTRY
TO MOVE FORWARD.

1284
00:55:43,133 --> 00:55:44,933
- ALL RIGHT, SO PLEASE JOIN ME
IN THANKING

1285
00:55:44,933 --> 00:55:47,833
NASA'S CHIEF SCIENTIST,
DR. ELLEN STOFAN.

1286
00:55:47,833 --> 00:55:50,033
[applause]