



1  
00:00:23,923 --> 00:00:34,801  
(French Music)

2  
00:00:34,801 --> 00:00:37,837  
- [Paul Butler] The famous  
Italian monk Giordano Bruno

3  
00:00:37,837 --> 00:00:40,639  
in 1586 published a book  
in which he said,

4  
00:00:40,639 --> 00:00:43,976  
"the sun is a star and that  
the earth was a planet,

5  
00:00:43,976 --> 00:00:46,779  
and that other stars certainly  
had planetary systems

6  
00:00:46,779 --> 00:00:48,648  
and probably even had life."

7  
00:00:48,648 --> 00:00:51,717  
And for that and other  
radical things that he said

8  
00:00:51,717 --> 00:00:54,253  
the church burned him publicly.

9  
00:00:54,253 --> 00:00:56,055  
You could say that  
extrasolar planets

10  
00:00:56,055 --> 00:00:59,091  
was a much hotter  
field back then.

11  
00:00:59,091 --> 00:01:04,029  
- [Debra Fischer] Exoplanets

were almost as silly as

12

00:01:04,129 --> 00:01:07,566

looking for extraterrestrials,  
you know, little green men

13

00:01:07,566 --> 00:01:09,169

on other planets.

14

00:01:09,169 --> 00:01:11,804

- [Didier Queloz] Seriously,  
looking for planets

15

00:01:11,804 --> 00:01:15,875

was a kind of weird topic.

16

00:01:15,875 --> 00:01:19,045

- The whole field had sort of a  
snake oil sheen about it

17

00:01:19,045 --> 00:01:22,882

because over the previous 50  
years or so there have been

18

00:01:22,882 --> 00:01:26,052

many many claims of the first  
extrasolar planet ever

19

00:01:26,052 --> 00:01:27,954

and the one thing all those  
claims had in common

20

00:01:27,954 --> 00:01:29,923

was they were wrong.

21

00:01:43,469 --> 00:01:46,239

- [Voiceover] In San Francisco,  
California, astronomers

22

00:01:46,239 --> 00:01:49,876  
Geoff Marcy and Paul Butler  
were quietly looking

23  
00:01:49,876 --> 00:01:51,344  
for doppler shifts;

24  
00:01:51,344 --> 00:01:55,348  
changes in the observed color  
of light from the star.

25  
00:01:55,348 --> 00:01:59,952  
- I literally spent the first  
eight years of the program

26  
00:01:59,952 --> 00:02:02,755  
simply trying to improve  
the techniques involved

27  
00:02:02,755 --> 00:02:05,391  
in making these sort  
of measurements.

28  
00:02:05,391 --> 00:02:07,793  
Mostly totally under the radar,  
nobody knew what we were doing

29  
00:02:07,793 --> 00:02:09,229  
and nobody cared.

30  
00:02:09,229 --> 00:02:11,530  
- [Voiceover] A ray of hope  
that it might be possible

31  
00:02:11,530 --> 00:02:14,166  
to detect a planet came  
with the discovery by

32  
00:02:14,166 --> 00:02:16,903  
Dave Latham and Tsevi Mazeh,

33

00:02:16,903 --> 00:02:23,108  
of a mysterious object  
orbiting the star HD114762.

34

00:02:23,108 --> 00:02:25,944  
- They announced the  
detection of an object

35

00:02:25,944 --> 00:02:27,647  
that they called a brown dwarf.

36

00:02:27,647 --> 00:02:30,350  
They looked, and they didn't  
see it in a telescope

37

00:02:30,350 --> 00:02:31,717  
so if it was a star

38

00:02:31,717 --> 00:02:33,919  
if it was a thousand times  
the mass of Jupiter,

39

00:02:33,919 --> 00:02:35,421  
they would have seen it.

40

00:02:35,421 --> 00:02:38,424  
- [Voiceover] To this day it is  
not known whether this object

41

00:02:38,424 --> 00:02:42,661  
is a planet, a brown dwarf  
or even a low-mass star.

42

00:02:42,661 --> 00:02:47,667  
But its discovery emboldened  
others to continue the search.

43

00:02:49,435 --> 00:02:52,738

A different and dangerous  
approach to planet hunting

44

00:02:52,738 --> 00:02:54,974  
was underway in Canada.

45

00:02:54,974 --> 00:02:57,309  
The team of Gordon Walker  
and Bruce Campbell

46

00:02:57,309 --> 00:03:00,846  
employed the deadly  
gas Hydrogen Fluoride

47

00:03:00,846 --> 00:03:04,416  
in an attempt to precisely  
measure Doppler shifts.

48

00:03:04,416 --> 00:03:08,754  
- [Paul] And he showed me their  
setup in Canada at one point.

49

00:03:08,754 --> 00:03:10,489  
One person would be in  
there doing the setup.

50

00:03:10,489 --> 00:03:12,558  
And the other person would have  
been outside of the room

51

00:03:12,558 --> 00:03:15,628  
looking through a porthole  
with two gas masks.

52

00:03:15,628 --> 00:03:18,665  
And his job was if something  
went wrong, throw on a gas mask,

53

00:03:18,665 --> 00:03:20,967  
run into the room, throw the

gas mask on the other guy

54

00:03:20,967 --> 00:03:22,902  
and drag him the hell out.

55

00:03:22,902 --> 00:03:25,071  
Any good science should  
have an element of danger.

56

00:03:25,071 --> 00:03:26,305  
There should always  
be at least

57

00:03:26,305 --> 00:03:28,208  
the vague hint of  
death involved.

58

00:03:28,208 --> 00:03:31,677  
Otherwise you're not really  
on the cutting edge.

59

00:03:31,677 --> 00:03:34,379  
They really pioneered  
the whole field.

60

00:03:34,379 --> 00:03:36,682  
Just a spectacular achievement.

61

00:03:36,682 --> 00:03:39,619  
- We're all here because of  
the work that they did.

62

00:03:43,222 --> 00:03:47,059  
- [Voiceover] In 1992, another  
incredible discovery piqued the

63

00:03:47,059 --> 00:03:49,828  
interest of astronomers  
looking for exoplanets.

64

00:03:49,828 --> 00:03:54,767

But these knew exoplanets were not orbiting a regular star.

65

00:03:54,767 --> 00:03:57,003

They were orbiting a pulsar.

66

00:03:57,003 --> 00:04:01,540

- [Jill Tarter] Two very small bodies got detected at Arecibo

67

00:04:01,540 --> 00:04:05,011

by Wolszczan and his colleagues.

68

00:04:05,011 --> 00:04:08,714

And they really got us scratching our heads.

69

00:04:08,714 --> 00:04:11,550

So, we call them pulsar planets.

70

00:04:11,550 --> 00:04:13,619

- Wolszczan and Frail is somewhat of a special case

71

00:04:13,619 --> 00:04:16,088

because I don't think anyone really doubted

72

00:04:16,088 --> 00:04:18,891

that these were planets as much at the time,

73

00:04:18,891 --> 00:04:22,261

but they were planets around a bizarre object, a pulsar.

74

00:04:22,261 --> 00:04:27,267

- But they really were the first two bodies to orbit...

75

00:04:30,335 --> 00:04:34,140

a dead star, not a currently shining star.

76

00:04:34,140 --> 00:04:37,176

- The formation of planets is an incredibly robust process.

77

00:04:37,176 --> 00:04:40,078

And that's what that discovery told us and we missed it

78

00:04:40,078 --> 00:04:42,347

because we didn't understand it.

79

00:04:42,347 --> 00:04:47,119

- We should've understood that planets don't come in one's,

80

00:04:47,119 --> 00:04:48,654

that they come in systems,

81

00:04:48,654 --> 00:04:53,660

but we were still focused on finding the very first planet.

82

00:04:58,264 --> 00:05:00,700

- [Voiceover] Half way around the world in Geneva,

83

00:05:00,866 --> 00:05:02,501

a pair of Swiss astronomers

84

00:05:02,501 --> 00:05:06,171

were hard at work developing a different technique.

85

00:05:06,171 --> 00:05:09,508

Their instrument relied on  
fiber optic technology,

86

00:05:09,508 --> 00:05:12,645

and they used it to turn  
their eyes on exoplanets.

87

00:05:12,645 --> 00:05:16,982

- My first day of work, I  
got this booklet from Michel

88

00:05:16,982 --> 00:05:19,986

that was the ultimate  
knowledge of data processing

89

00:05:19,986 --> 00:05:23,756

of spectroscopy, there was  
almost nothing at that time.

90

00:05:23,756 --> 00:05:26,993

to do this, this instrument.  
And that's it, and we had

91

00:05:26,993 --> 00:05:30,128

And we designed it, practically,  
without much support

92

00:05:30,128 --> 00:05:31,897

from anybody else because  
the other people

93

00:05:31,897 --> 00:05:34,167

felt that this was  
not interesting.

94

00:05:34,167 --> 00:05:38,638

- [Michel Mayor] After a few  
months, already at the end

95

00:05:38,638 --> 00:05:45,411  
of '94, we got a signal of  
viability for several stars,

96

00:05:45,411 --> 00:05:47,579  
not only one, several stars.

97

00:05:47,579 --> 00:05:49,481  
- We realized very rapidly  
that the instrument

98

00:05:49,481 --> 00:05:51,783  
could be far more precise  
than we thought.

99

00:05:51,783 --> 00:05:54,354  
So I started with a couple of  
star a bit more intensively

100

00:05:54,354 --> 00:05:56,856  
and 51-Peg was one of them  
because it was bright.

101

00:05:56,856 --> 00:06:00,559  
And very rapidly, 51-Peg  
had a very weird behavior.

102

00:06:00,559 --> 00:06:03,929  
- On one side we were  
absolutely sure of the

103

00:06:03,929 --> 00:06:05,664  
quality of our measurement.

104

00:06:05,664 --> 00:06:09,435  
All the signal was in  
favor of a planet,

105

00:06:09,435 --> 00:06:13,439

but it's evident it was  
a so unusual planet.

106  
00:06:13,439 --> 00:06:16,008  
- I really thought at that  
time, oh there is something

107  
00:06:16,008 --> 00:06:18,844  
really bad in the software  
and the instruments

108  
00:06:18,844 --> 00:06:20,946  
and I better to figure out,  
because otherwise

109  
00:06:20,946 --> 00:06:23,582  
my Phd will be compromised.

110  
00:06:23,582 --> 00:06:25,818  
- [Voiceover] Over the  
next several months,

111  
00:06:25,818 --> 00:06:29,355  
the two astronomers checked  
and re-checked their data.

112  
00:06:29,355 --> 00:06:32,658  
The problem was no one could  
imagine a giant planet

113  
00:06:32,658 --> 00:06:34,727  
with such a short orbit.

114  
00:06:34,727 --> 00:06:38,965  
- So, we came back in July, this  
time together with Michel.

115  
00:06:38,965 --> 00:06:43,536  
Very excited, I said okay,  
lo--let's see whether

116

00:06:43,536 --> 00:06:46,505

the conclusion that we had  
with the first bunch of data

117

00:06:46,505 --> 00:06:48,607

we had still holds.

118

00:06:48,607 --> 00:06:54,713

- The real moment where we had  
the confirmation of the reality

119

00:06:54,713 --> 00:07:00,452

of 51-Peg was really a  
planet was in July '95.

120

00:07:00,452 --> 00:07:05,157

- First data up, just on it,  
We said, ok, just luck.

121

00:07:05,157 --> 00:07:08,694

Second data, still on the curve.

122

00:07:08,694 --> 00:07:12,398

We said, ok well two is far  
but still two is not enough.

123

00:07:12,398 --> 00:07:15,567

The third one was still on it,  
following a track, I mean,

124

00:07:15,567 --> 00:07:19,638

and then we say well, let's  
just wait the fourth...

125

00:07:19,638 --> 00:07:21,073

to be really really sure.

126

00:07:21,073 --> 00:07:23,642

Because it was so, so, so  
embarrassing conclusion

127

00:07:23,642 --> 00:07:25,812

that planet that we really  
wanted to make sure that

128

00:07:25,812 --> 00:07:27,279

that was real.

129

00:07:27,279 --> 00:07:32,151

- We got the good period, the  
good amplitude and so on,

130

00:07:32,551 --> 00:07:36,422

so at the time was really the  
time for the celebration.

131

00:07:36,422 --> 00:07:38,356

Before we were not sure at  
that it was a planet.

132

00:07:38,356 --> 00:07:39,892

- I mean there is a real planet.

133

00:07:39,892 --> 00:07:44,363

Believe it or not, there is no  
theory to predict that planet,

134

00:07:44,363 --> 00:07:47,600

but there is a planet there.

135

00:07:49,401 --> 00:07:52,604

- [Voiceover] Following days  
of rumor circling the globe,

136

00:07:53,338 --> 00:07:55,774

at a conference in  
Florence, Italy,

137

00:07:55,774 --> 00:07:58,343

the news unofficially leaked.

138

00:07:58,343 --> 00:08:01,680

A Jupiter-sized planet  
had been discovered.

139

00:08:01,680 --> 00:08:06,084

This massive planet was making  
a complete orbit of its star

140

00:08:06,084 --> 00:08:08,353

in only four days.

141

00:08:08,353 --> 00:08:10,422

How could that be?

142

00:08:10,422 --> 00:08:13,625

- Suddenly there's this 51-Peg  
which is a Jupiter-sized planet,

143

00:08:13,625 --> 00:08:15,294

but in a four day orbit.

144

00:08:15,294 --> 00:08:17,463

Well, people knew that  
was impossible.

145

00:08:17,463 --> 00:08:18,931

Jupiter-like planets

146

00:08:18,931 --> 00:08:21,367

orbit at like-Jupiter and  
Saturn orbital distances.

147

00:08:21,367 --> 00:08:24,469

- [Voiceover] Back in San  
Francisco, Marcy and Butler,

148

00:08:24,469 --> 00:08:27,739

by mere coincidence, had  
four consecutive days

149

00:08:27,739 --> 00:08:30,943

of reserved telescope time at  
the Lick Observatory -

150

00:08:30,943 --> 00:08:35,381

the exact amount of time needed  
to confirm or debunk the claim.

151

00:08:38,750 --> 00:08:41,686

- [Paul] We hit the star very  
hard for those four nights.

152

00:08:41,686 --> 00:08:45,458

We reduced the data  
as quickly as we can.

153

00:08:45,458 --> 00:08:46,358

We were blown away.

154

00:08:46,358 --> 00:08:47,492

We saw exactly the signal

155

00:08:47,492 --> 00:08:49,928

that Mayor and Queloz  
had announced.

156

00:08:49,928 --> 00:08:54,299

- Confirming my data,

157

00:08:54,299 --> 00:08:57,202

to me was just the best  
gift I could have had.

158

00:08:57,202 --> 00:09:02,141

Because I said, oh fine, so

all the work I did is right.

159

00:09:05,678 --> 00:09:08,281

- [News Announcer] Here in San Francisco the discovery

160

00:09:08,281 --> 00:09:11,384

was dramatically verified just this past weekend

161

00:09:11,384 --> 00:09:14,420

- [News Announcer] October 19th, 1995.

162

00:09:14,420 --> 00:09:18,490

- [Ted Koppel] what may be the discovery of new planets

163

00:09:18,490 --> 00:09:22,995

outside our solar system has created enormous excitement

164

00:09:22,995 --> 00:09:24,129

among astronomers.

165

00:09:24,129 --> 00:09:25,964

[Voiceover] The confirmation was made

166

00:09:25,964 --> 00:09:29,935

before the official announcement of the discovery itself.

167

00:09:29,935 --> 00:09:32,104

- It went completely out of control.

168

00:09:32,104 --> 00:09:36,208

- Everybody was discussing of this new object except us.

169

00:09:36,208 --> 00:09:38,777

- [Voiceover] By tradition,  
scientists have their

170

00:09:38,777 --> 00:09:42,547

discoveries peer reviewed by  
other scientists for accuracy.

171

00:09:42,547 --> 00:09:45,317

- [Alan Boss] I was one of  
the referees on the paper.

172

00:09:45,317 --> 00:09:46,818

There were three referees.

173

00:09:46,818 --> 00:09:50,723

And normally I think they only  
do two, but this was so big

174

00:09:50,723 --> 00:09:54,059

that the Nature editor, Leslie  
Sage, was being very careful.

175

00:09:54,059 --> 00:09:56,362

- Because of the situations,  
Nature was very strict.

176

00:09:56,362 --> 00:09:59,531

They said "Well look guys,  
if you talk to people,

177

00:09:59,531 --> 00:10:01,700

then we're not going to  
publish your paper."

178

00:10:01,700 --> 00:10:05,203

- So, it's only after one month  
or something like this

179

00:10:05,203 --> 00:10:07,740

that I receive a message  
from Nature that

180

00:10:07,740 --> 00:10:12,144

ok, now you are relaxed  
from the embargo.

181

00:10:12,144 --> 00:10:13,779

- Because the discovery  
of was just too big,

182

00:10:13,779 --> 00:10:19,618

just far too big to  
follow the usual scheme

183

00:10:19,618 --> 00:10:21,687

that is required for  
scientific paper.

184

00:10:21,687 --> 00:10:23,222

As soon as you start  
talking about that,

185

00:10:23,222 --> 00:10:25,023

I mean everybody wanted  
to know about this.

186

00:10:25,023 --> 00:10:30,029

- 51 Peg B is a real planet,  
no question about that.

187

00:10:33,565 --> 00:10:35,034

- As soon as we detected 51-Peg,

188

00:10:35,034 --> 00:10:38,203

he had on his data plenty  
of something like that.

189

00:10:38,203 --> 00:10:39,639

He just need to look at it.

190

00:10:39,639 --> 00:10:41,173

- At this point we hadn't analyzed all our data.

191

00:10:41,173 --> 00:10:42,440

We had two computers,

192

00:10:42,440 --> 00:10:43,809

and it would have literally have taken us

193

00:10:43,809 --> 00:10:46,478

five or six years to get through all of the data.

194

00:10:46,478 --> 00:10:49,448

So, literally about a half a dozen different groups said

195

00:10:49,448 --> 00:10:52,484

"You know we've just received these new computers and

196

00:10:52,484 --> 00:10:54,419

we're not gonna use them for the next several months.

197

00:10:54,419 --> 00:10:56,488

You wanna dump your jobs on it?"

198

00:10:56,488 --> 00:10:59,325

- [Voiceover] Within two months, two other "Jupiters"

199

00:10:59,325 --> 00:11:02,227

circling around their stars were found by Marcy and Butler

200

00:11:02,227 --> 00:11:07,232  
and the floodgates of planet  
hunting were now wide open.

201

00:11:08,000 --> 00:11:11,870  
- You know from no planets  
at all to the point

202

00:11:11,870 --> 00:11:14,205  
where we were discovering  
a new planet every month

203

00:11:14,205 --> 00:11:16,108  
or even sometimes every week.

204

00:11:16,108 --> 00:11:18,677  
And almost all of the planetary  
systems that we found

205

00:11:18,677 --> 00:11:20,679  
were very different from  
the Solar System.

206

00:11:20,679 --> 00:11:22,881  
Weren't even similar  
in the least bit.

207

00:11:22,881 --> 00:11:25,217  
- I remember asking  
at a meeting,

208

00:11:25,217 --> 00:11:27,485  
you know "How long do you  
think this will go on?"

209

00:11:27,485 --> 00:11:28,787  
And I think Michel Mayor said,

210

00:11:28,787 --> 00:11:31,290  
"Oh maybe, you know, another  
five or ten years,

211  
00:11:31,290 --> 00:11:33,592  
and then the game is over."

212  
00:11:33,592 --> 00:11:35,961  
Fortunately, the game just  
got a lot more exciting.

213  
00:11:45,571 --> 00:11:47,839  
- [Natalie Batalha] After  
getting my PhD,

214  
00:11:47,839 --> 00:11:49,608  
I became aware of this fellow

215  
00:11:49,608 --> 00:11:52,310  
at NASA Ames Research  
Center, Bill Borucki.

216  
00:11:52,310 --> 00:11:54,112  
- I would see him at  
all these meetings.

217  
00:11:54,112 --> 00:11:56,348  
They were very small meetings  
back in the day.

218  
00:11:56,348 --> 00:11:58,483  
And like he'd literally be by  
himself out having dinner,

219  
00:11:58,483 --> 00:12:00,218  
so we would join him  
and chat about things

220  
00:12:00,218 --> 00:12:01,954  
and he was very persistent.

221

00:12:01,954 --> 00:12:04,823

- Bill walked around the halls  
and whenever the Ames managers

222

00:12:04,823 --> 00:12:09,394

saw him coming they turned  
and walked the other way.

223

00:12:09,394 --> 00:12:11,497

- Bill Borucki wrote  
a paper in the 1980s

224

00:12:11,497 --> 00:12:14,199

that described  
the Transit Method.

225

00:12:14,199 --> 00:12:16,034

When that planet passes  
in front of the star,

226

00:12:16,034 --> 00:12:18,703

the starlight drops  
by a tiny, tiny amount.

227

00:12:18,703 --> 00:12:21,440

And by measuring the brightness  
of the star minute by minute,

228

00:12:21,440 --> 00:12:23,808

we can detect planets going  
in front of the star.

229

00:12:23,808 --> 00:12:25,644

And we call that  
the Transit Method.

230

00:12:25,644 --> 00:12:28,647

And detectors that could measure  
that precise drop in brightness

231

00:12:28,647 --> 00:12:29,982  
didn't exist yet.

232

00:12:29,982 --> 00:12:31,416  
- To be successful all  
one needed to do

233

00:12:31,416 --> 00:12:32,818  
was build a photometer

234

00:12:32,818 --> 00:12:35,787  
a thousand times better  
than anyone ever built one.

235

00:12:35,787 --> 00:12:37,088  
But I'd worked on  
the Apollo program,

236

00:12:37,088 --> 00:12:38,123  
I've worked on other programs.

237

00:12:38,123 --> 00:12:39,858  
So that's not really that scary.

238

00:12:39,858 --> 00:12:43,562  
You just need to get down  
to brass tacks, and

239

00:12:43,562 --> 00:12:48,567  
find out what's required,  
and build it.

240

00:12:49,001 --> 00:12:53,705  
There just is no way of  
finding small planets

241

00:12:53,705 --> 00:12:55,707  
in orbits like that

of the earth,

242

00:12:55,707 --> 00:12:58,511  
unless you go into space. You  
must go into space.

243

00:12:58,511 --> 00:13:00,846  
- He kept getting shot down  
by the review panels

244

00:13:00,846 --> 00:13:03,482  
for various reasons, and each  
time he'd fix the reason

245

00:13:03,482 --> 00:13:04,683  
and go back a second time.

246

00:13:04,683 --> 00:13:06,719  
They basically said  
it's not gonna work.

247

00:13:06,719 --> 00:13:08,954  
Well, Bill Borucki didn't  
bother reading that report.

248

00:13:08,954 --> 00:13:10,622  
Or at least he did not  
take it to heart.

249

00:13:10,622 --> 00:13:12,290  
He kept on his crusade  
to show that

250

00:13:12,290 --> 00:13:13,892  
transit detection should work.

251

00:13:13,892 --> 00:13:15,561  
- [Sara] And he was able to  
demonstrate in the lab

252

00:13:15,561 --> 00:13:17,462

that he could measure the  
precision required

253

00:13:17,462 --> 00:13:19,831

to find earth-sized planets  
orbiting sun-like stars.

254

00:13:19,831 --> 00:13:21,767

- Some people call  
it stubbornness,

255

00:13:21,767 --> 00:13:24,536

but the point is  
I knew it would work.

256

00:13:24,536 --> 00:13:26,604

- So he proposed, and re-  
proposed, and eventually

257

00:13:26,604 --> 00:13:28,540

he conceived of a Discovery  
Class mission

258

00:13:28,540 --> 00:13:30,209

that was later called Kepler.

259

00:13:30,209 --> 00:13:34,446

- It was 25 years between  
the date of publication

260

00:13:34,446 --> 00:13:36,881

and the date that Kepler  
actually launched.

261

00:13:36,881 --> 00:13:38,717

- [TV Announcer] ...one, zero!

262

00:13:38,717 --> 00:13:42,221

And liftoff for the Delta 2  
rocket with Kepler...

263

00:13:42,221 --> 00:13:47,226  
on a search for planets in  
someway like our own.

264

00:13:50,128 --> 00:13:52,364  
- Kepler just delivered so much  
tremendously new things

265

00:13:52,364 --> 00:13:53,932  
we never even conceived of.

266

00:13:53,932 --> 00:13:57,335  
And the things that were on our  
wish list, Kepler found for us.

267

00:13:57,335 --> 00:13:59,405  
- This data was being displayed  
for the first time

268

00:13:59,405 --> 00:14:01,407  
on the computer monitors.

269

00:14:01,407 --> 00:14:04,609  
And there was the transit of  
that Jupiter-sized planet

270

00:14:04,609 --> 00:14:08,480  
and the data was like  
beads on a string.

271

00:14:08,480 --> 00:14:10,282  
- [James Fanson] Kepler's  
transformed our

272

00:14:10,282 --> 00:14:11,984  
understanding of exoplanets.

273

00:14:11,984 --> 00:14:14,052

What Kepler was designed  
to do specifically

274

00:14:14,052 --> 00:14:18,456

was to go after terrestrial  
or rocky planets

275

00:14:18,456 --> 00:14:21,693

that are in closer  
orbits to stars.

276

00:14:21,693 --> 00:14:25,664

We now know from the  
Kepler data, that planets

277

00:14:25,664 --> 00:14:29,301

like the earth are in fact  
common in the galaxy.

278

00:14:29,301 --> 00:14:30,502

And that's something

279

00:14:30,502 --> 00:14:33,605

we fundamentally didn't  
know before Kepler.

280

00:14:33,605 --> 00:14:35,373

- The first exoplanet  
was already diverse

281

00:14:35,373 --> 00:14:38,076

and Kepler continued to  
find more and more planets

282

00:14:38,076 --> 00:14:42,414

that didn't fit the norm...both  
in the size, in composition,

283

00:14:42,414 --> 00:14:43,915  
in distance from their star.

284

00:14:43,915 --> 00:14:47,485  
So when you think about how many  
stars there are in our galaxy,

285

00:14:47,485 --> 00:14:50,688  
a few hundred billion, and if  
each one has one or maybe more,

286

00:14:50,688 --> 00:14:53,792  
we're looking at a few  
hundred billion planets.

287

00:14:53,792 --> 00:14:56,528  
- [Natalie] To accomplish  
something great,

288

00:14:56,528 --> 00:14:59,064  
you have to have persistence.

289

00:14:59,064 --> 00:15:00,466  
- To succeed in exoplanets,

290

00:15:00,466 --> 00:15:04,202  
we have to be very  
ambitious and very bold.

291

00:15:04,202 --> 00:15:06,404  
- Kepler's impact was extreme,

292

00:15:06,404 --> 00:15:09,274  
certainly more than I  
ever ever imagined.

293

00:15:09,274 --> 00:15:14,280  
It's basically opened up  
an entire new era of astronomy.

294

00:15:30,161 --> 00:15:33,332

- Now that we know that the galaxy is teeming with planets

295

00:15:33,332 --> 00:15:36,201

we are ready to go to the next chapter

296

00:15:36,201 --> 00:15:37,603

of planetary exploration.

297

00:15:37,603 --> 00:15:40,205

- [Jason Kalirai] I truly believe that the 2020s

298

00:15:40,205 --> 00:15:41,573

are shaping up to be a Golden Age

299

00:15:41,573 --> 00:15:43,242

for observational astrophysics.

300

00:15:43,242 --> 00:15:46,011

You know we have these amazing telescopes like TESS,

301

00:15:46,011 --> 00:15:48,446

the Transiting Exoplanet Survey Satellite.

302

00:15:48,446 --> 00:15:51,282

We have WFIRST, which is this Hubble-sized telescope

303

00:15:51,282 --> 00:15:54,886

that can see a hundred times as much of the sky in each image.

304

00:15:54,886 --> 00:15:57,856

We have the James Webb  
Space Telescope which is

305

00:15:57,856 --> 00:16:00,726

the largest and most powerful  
telescope we've ever built.

306

00:16:00,726 --> 00:16:03,929

You know the reason we can even  
dream about that and

307

00:16:03,929 --> 00:16:06,431

create something like that  
is because of the success of

308

00:16:06,431 --> 00:16:09,734

Spitzer and Hubble and the  
previous great observatories.

309

00:16:09,734 --> 00:16:11,736

- I'm looking forward to  
space-based missions

310

00:16:11,736 --> 00:16:13,839

where they're gonna have  
coronagraph technology

311

00:16:13,839 --> 00:16:16,742

and maybe even star-shield  
technology in order to

312

00:16:16,742 --> 00:16:21,747

image exoplanets by blocking  
out the light from stars.

313

00:16:21,947 --> 00:16:25,150

- And we have the next  
generation large

314

00:16:25,150 --> 00:16:27,385

30-meter class telescopes  
on the ground

315

00:16:27,385 --> 00:16:31,189

which are gonna be coming  
online in the 2020s.

316

00:16:31,189 --> 00:16:33,458

But the question that  
has me most excited

317

00:16:33,458 --> 00:16:37,061

about the future of astronomy  
is to answer the question:

318

00:16:37,061 --> 00:16:42,067

Are we alone in the universe?

319

00:16:43,402 --> 00:16:46,304

- Finding evidence of  
life on an exoplanet,

320

00:16:46,304 --> 00:16:49,007

finding an indication  
of a living world,

321

00:16:49,007 --> 00:16:51,810

is within our reach.

322

00:16:51,810 --> 00:16:53,211

- What is life?

323

00:16:53,211 --> 00:16:56,914

Life is a process to  
transfer information

324

00:16:56,914 --> 00:16:59,618

from one generation to another.

325

00:16:59,618 --> 00:17:02,353

- Everybody is interested  
in the search for planets...

326

00:17:02,353 --> 00:17:05,157

the search for places  
that remind us of home.

327

00:17:05,157 --> 00:17:08,694

- [Scott] We're looking for  
some hint of our origins,

328

00:17:08,694 --> 00:17:10,062

where we came from,

329

00:17:10,062 --> 00:17:12,598

and exoplanets may very well  
provide that context.

330

00:17:12,598 --> 00:17:17,101

- [Jill] There may be more  
habitable real estate out there

331

00:17:17,101 --> 00:17:20,205

beyond our solar system  
than we once thought.

332

00:17:20,205 --> 00:17:23,508

- [Jason] I think we're  
naturally curious to find out

333

00:17:23,508 --> 00:17:25,577

if there are other conditions  
in the universe

334

00:17:25,577 --> 00:17:27,712

that might be  
similar to our own.

335

00:17:27,712 --> 00:17:30,315

And finding exoplanets  
around other stars

336

00:17:30,315 --> 00:17:32,451  
is the first important clue.

337

00:17:32,451 --> 00:17:36,354  
- [Debra] The search for  
planets is a search for life.

338

00:17:36,354 --> 00:17:39,190  
And even though we didn't  
really say that out loud,