1
00:00:08,230 --> 00:00:05,269
[Music]

2
00:00:10,390 --> 00:00:08,240
we have an innate curiosity

3
00:00:12,549 --> 00:00:10,400
about our origins

4
00:00:14,070 --> 00:00:12,559
is life in our galaxy

5
00:00:17,109 --> 00:00:14,080
common

6
00:00:19,189 --> 00:00:17,119
does it exist are we alone how unique is

7
00:00:21,830 --> 00:00:19,199
life here on earth

8
00:00:29,290 --> 00:00:21,840
the kepler mission is one step

9
00:00:40,310 --> 00:00:38,790
[Music]

10
00:00:43,110 --> 00:00:40,320
kepler mission

11
00:00:44,549 --> 00:00:43,120
is a huge step forward in answering the

12
00:00:47,430 --> 00:00:44,559
question

13
00:00:49,670 --> 00:00:47,440

what is our place in the universe

14
00:00:52,150 --> 00:00:49,680
the kepler mission is nasa's first

15
00:00:53,910 --> 00:00:52,160
mission capable of finding earth-like

16
00:00:56,069 --> 00:00:53,920
planets orbiting

17
00:00:58,229 --> 00:00:56,079
other stars in the galaxy

18
00:01:00,069 --> 00:00:58,239
in a region around the star we call the

19
00:01:03,910 --> 00:01:00,079
habitable zone

20
00:01:05,189 --> 00:01:03,920
water will be if you can find liquid

21
00:01:08,149 --> 00:01:05,199
water on the surface we think we may

22
00:01:09,830 --> 00:01:08,159
very well find life there so that zone

23
00:01:11,910 --> 00:01:09,840
is not too close to the star because

24
00:01:13,670 --> 00:01:11,920
it's too hot the water boils not too far

25
00:01:15,910 --> 00:01:13,680
away where the water is condensed in the

26
00:01:18,550 --> 00:01:15,920
ice covered plant covered with glaciers

27
00:01:23,190 --> 00:01:18,560
it's the goldilocks zone not too hot not

28
00:01:27,510 --> 00:01:26,070
the primary science goal of kepler is to

29
00:01:30,630 --> 00:01:27,520
answer the question if earth-like

30
00:01:32,630 --> 00:01:30,640
planets in our galaxy are common or rare

31
00:01:34,550 --> 00:01:32,640
kepler is going to detect planets via

32
00:01:36,469 --> 00:01:34,560
the transit method

33
00:01:38,550 --> 00:01:36,479
what we aim to do is to measure the

34
00:01:40,630 --> 00:01:38,560
brightnesses of stars very very

35
00:01:42,389 --> 00:01:40,640
accurately for a very long period of

36
00:01:44,310 --> 00:01:42,399
time without blinking

37
00:01:45,590 --> 00:01:44,320
so that when the planet passes in front

38
00:01:47,270 --> 00:01:45,600

of the star

39
00:01:49,350 --> 00:01:47,280
the light output from the star is going

40
00:01:52,230 --> 00:01:49,360
to dim just a little bit that star is

41
00:01:53,749 --> 00:01:52,240
going to blink for about 12 hours

42
00:01:56,310 --> 00:01:53,759
and we will be able to measure that dip

43
00:01:58,389 --> 00:01:56,320
in brightness and it's that dip that we

44
00:01:59,830 --> 00:01:58,399
call a transit

45
00:02:02,310 --> 00:01:59,840
kepler is a different animal from the

46
00:02:04,630 --> 00:02:02,320
hubble space telescope or the spitzer

47
00:02:06,789 --> 00:02:04,640
infrared telescope because it doesn't

48
00:02:09,109 --> 00:02:06,799
take pictures you won't see beautiful

49
00:02:11,430 --> 00:02:09,119
images that you see from hubble because

50
00:02:13,110 --> 00:02:11,440
we're not doing that kind of science

51
00:02:15,510 --> 00:02:13,120
those types of missions like hubble and

52
00:02:17,589 --> 00:02:15,520
spitzer are designed to focus on

53
00:02:19,830 --> 00:02:17,599
specific targets

54
00:02:22,309 --> 00:02:19,840
if you hold your hand

55
00:02:24,790 --> 00:02:22,319
at arm's length with a grain of salt or

56
00:02:26,630 --> 00:02:24,800
a grain of sand that's about how much of

57
00:02:29,030 --> 00:02:26,640
the sky you can see

58
00:02:31,509 --> 00:02:29,040
with a normal astronomical telescope at

59
00:02:32,390 --> 00:02:31,519
any one time kepler has a field of view

60
00:02:35,110 --> 00:02:32,400
that's

61
00:02:38,550 --> 00:02:35,120
10 degrees by 10 degrees our field of

62
00:02:40,869 --> 00:02:38,560
view is about as big as your hand at

63
00:02:42,949 --> 00:02:40,879

arm's length covering the sky

64
00:02:45,030 --> 00:02:42,959
so rather than taking pictures of very

65
00:02:46,949 --> 00:02:45,040
concentrated parts of the sky we're

66
00:02:49,110 --> 00:02:46,959
looking at taking a very broad snapshot

67
00:02:52,550 --> 00:02:49,120
of a lot of stars

68
00:02:54,470 --> 00:02:52,560
kepler takes really fuzzy pictures but

69
00:02:58,149 --> 00:02:54,480
the thing that kepler is designed to do

70
00:03:00,149 --> 00:02:58,159
and it does very well is look for very

71
00:03:02,790 --> 00:03:00,159
small variations in the brightness of

72
00:03:04,869 --> 00:03:02,800
the stars an earth-like planet passing

73
00:03:06,470 --> 00:03:04,879
in front of a sun-like star

74
00:03:09,030 --> 00:03:06,480
is going to cause the brightness of that

75
00:03:11,030 --> 00:03:09,040
star to dim by only one part per ten

76
00:03:13,030 --> 00:03:11,040
thousand

77
00:03:15,990 --> 00:03:13,040
that's like looking at a headlight from

78
00:03:18,149 --> 00:03:16,000
a great distance and trying to sense the

79
00:03:19,670 --> 00:03:18,159
brightness change when a flea crawls

80
00:03:22,470 --> 00:03:19,680
across the surface

81
00:03:25,910 --> 00:03:22,480
but the kepler instrument is designed to

82
00:03:29,030 --> 00:03:25,920
detect such small changes in brightness

83
00:03:31,670 --> 00:03:29,040
the kepler sensors are ccds

84
00:03:33,030 --> 00:03:31,680
the ccd in your camera is about

85
00:03:34,630 --> 00:03:33,040
the size of one of your small

86
00:03:37,750 --> 00:03:34,640
fingernails

87
00:03:40,470 --> 00:03:37,760
the ccd chips on kepler are a couple of

88
00:03:42,630 --> 00:03:40,480

inches square in pairs

89
00:03:44,229 --> 00:03:42,640
and there's 42 of those

90
00:03:46,070 --> 00:03:44,239
in your camera you might have a few

91
00:03:49,830 --> 00:03:46,080
megapixels if you have a really nice

92
00:03:53,270 --> 00:03:49,840
camera you might have 10 megapixels

93
00:03:55,750 --> 00:03:53,280
we have 96 million pixels and they have

94
00:03:58,070 --> 00:03:55,760
very low noise so we can find very small

95
00:04:00,309 --> 00:03:58,080
planets

96
00:04:01,750 --> 00:04:00,319
once kepler is launched from the earth

97
00:04:03,670 --> 00:04:01,760
it will go into what's called an earth

98
00:04:05,589 --> 00:04:03,680
trailing orbit

99
00:04:07,830 --> 00:04:05,599
astronomers call that a heliocentric

100
00:04:09,509 --> 00:04:07,840
orbit which means sun-centered orbit it

101
00:04:12,630 --> 00:04:09,519
looks at the stars continuously day and

102
00:04:14,470 --> 00:04:12,640
night 365 days a year and it slowly

103
00:04:15,830 --> 00:04:14,480
moves away from the earth orbiting the

104
00:04:18,229 --> 00:04:15,840
sun by itself

105
00:04:20,550 --> 00:04:18,239
and from there we'll point itself at the

106
00:04:22,629 --> 00:04:20,560
kepler field and stare

107
00:04:24,629 --> 00:04:22,639
at the kepler field nearly without

108
00:04:26,310 --> 00:04:24,639
blinking for three and a half years at

109
00:04:28,629 --> 00:04:26,320
least maybe longer if we have an

110
00:04:30,390 --> 00:04:28,639
extended mission

111
00:04:33,110 --> 00:04:30,400
kepler will be looking in a region of

112
00:04:35,350 --> 00:04:33,120
the sky that you'll see almost every

113
00:04:37,110 --> 00:04:35,360

night in the summertime the field of

114
00:04:39,510 --> 00:04:37,120
view is kind of nestled underneath the

115
00:04:41,270 --> 00:04:39,520
wing of cygnus the swan between cygnus

116
00:04:43,510 --> 00:04:41,280
and lyra

117
00:04:45,430 --> 00:04:43,520
now in that area of sky

118
00:04:47,030 --> 00:04:45,440
there are something like six and a half

119
00:04:48,710 --> 00:04:47,040
million stars

120
00:04:50,310 --> 00:04:48,720
why do we need so many

121
00:04:52,550 --> 00:04:50,320
because of the way kepler looks for

122
00:04:54,710 --> 00:04:52,560
planets we have to have planetary

123
00:04:57,030 --> 00:04:54,720
systems that are lined up so that the

124
00:04:59,510 --> 00:04:57,040
planet actually passes between the star

125
00:05:01,189 --> 00:04:59,520
and kepler telescope in its orbit the

126
00:05:03,110 --> 00:05:01,199
probability of that happening if you

127
00:05:04,790 --> 00:05:03,120
just throw stars randomly down in our

128
00:05:06,310 --> 00:05:04,800
galaxy is something like one to ten

129
00:05:08,070 --> 00:05:06,320
percent it's small

130
00:05:10,870 --> 00:05:08,080
so of those six and a half million

131
00:05:14,550 --> 00:05:10,880
scattered over that 100 square degrees

132
00:05:17,430 --> 00:05:14,560
only maybe 200 000 are interesting to us

133
00:05:20,310 --> 00:05:17,440
we select 170 000 or so that are most

134
00:05:22,230 --> 00:05:20,320
suitable to look at for planets with the

135
00:05:24,230 --> 00:05:22,240
kepler telescope

136
00:05:26,790 --> 00:05:24,240
finally we expect to end up with

137
00:05:28,230 --> 00:05:26,800
somewhere between a few hundred and a

138
00:05:30,310 --> 00:05:28,240

few thousand

139
00:05:33,670 --> 00:05:30,320
signals that are really planets around

140
00:05:37,189 --> 00:05:35,590
well this is the first time that

141
00:05:39,590 --> 00:05:37,199
photometry the measurement of the

142
00:05:41,590 --> 00:05:39,600
brightness of stars will ever be done at

143
00:05:43,990 --> 00:05:41,600
this level of precision

144
00:05:46,629 --> 00:05:44,000
and it will be done simultaneously on

145
00:05:49,590 --> 00:05:46,639
more than 100 000 stars continuously

146
00:05:52,710 --> 00:05:49,600
over a period of years

147
00:05:54,870 --> 00:05:52,720
we're somewhat like pioneers very much

148
00:05:57,510 --> 00:05:54,880
like the explorers that were looking for

149
00:05:59,270 --> 00:05:57,520
new lands to settle and that's how i see

150
00:06:01,590 --> 00:05:59,280
what we're doing we're looking in this

151
00:06:03,029 --> 00:06:01,600
region of our galaxy for other habitable

152
00:06:05,510 --> 00:06:03,039
worlds

153
00:06:07,270 --> 00:06:05,520
i think people everywhere want to know

154
00:06:09,749 --> 00:06:07,280
whether with all the stars out there do

155
00:06:12,870 --> 00:06:09,759
they have planets that are earth-sized

156
00:06:15,430 --> 00:06:12,880
are earth frequent or are they rare

157
00:06:18,070 --> 00:06:15,440
and this gives us that answer

158
00:06:19,590 --> 00:06:18,080
it's the next step mankind's exploration

159
00:06:21,830 --> 00:06:19,600
of the galaxy

160
00:06:22,950 --> 00:06:21,840
there's two extreme answers that kepler

161
00:06:24,550 --> 00:06:22,960
might give us

162
00:06:26,629 --> 00:06:24,560
it might tell us that there's an

163
00:06:28,790 --> 00:06:26,639

earth-like planet practically around

164
00:06:29,909 --> 00:06:28,800
every star we look at

165
00:06:31,990 --> 00:06:29,919
imagine

166
00:06:34,629 --> 00:06:32,000
the possibilities for for life in the

167
00:06:36,390 --> 00:06:34,639
galaxy or life in the universe if on the

168
00:06:39,029 --> 00:06:36,400
other hand we found out that earth was

169
00:06:41,110 --> 00:06:39,039
very special and that the typical star

170
00:06:43,189 --> 00:06:41,120
like the sun is not

171
00:06:44,950 --> 00:06:43,199
hosting planets like the earth i think

172
00:06:46,710 --> 00:06:44,960
that would be a real surprise as well

173
00:06:49,189 --> 00:06:46,720
and would really make us

174
00:06:51,670 --> 00:06:49,199
reconsider the special nature of earth

175
00:06:54,469 --> 00:06:51,680
we are now finally at the point where

176
00:06:55,510 --> 00:06:54,479
our technology allows us to build a

177
00:06:57,189 --> 00:06:55,520
machine

178
00:06:59,909 --> 00:06:57,199
that can make the observations to

179
00:07:02,469 --> 00:06:59,919
scientifically answer this question

180
00:07:04,790 --> 00:07:02,479
how many stars like the sun did develop

181
00:07:05,909 --> 00:07:04,800
planets around them like the earth

182
00:07:07,350 --> 00:07:05,919
i think that's such an important

183
00:07:08,790 --> 00:07:07,360
question to everyone and so interesting

184
00:07:15,010 --> 00:07:08,800
that we really have to do it and it's a