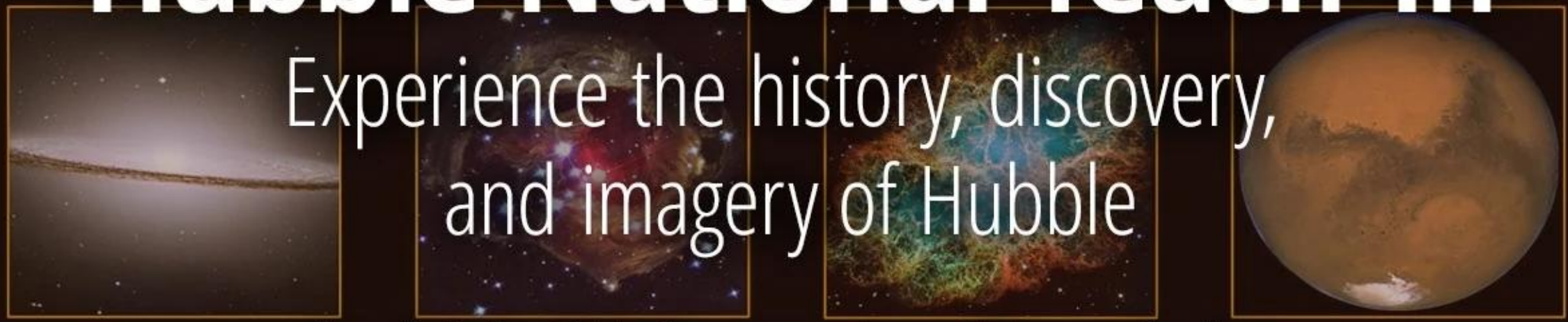
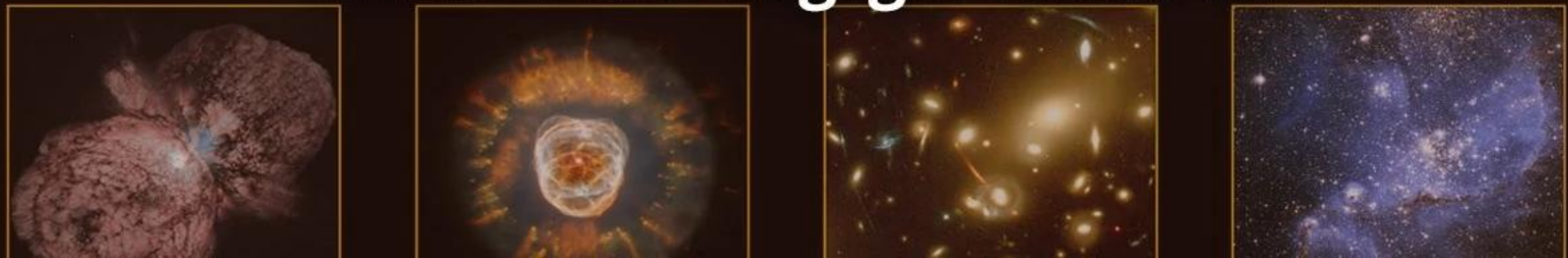
Hubble National Teach-In

Experience the history, discovery,
and imagery of Hubble



hubble25th.org/go/Teach-In



1
00:00:07,700 --> 00:00:05,240
hi I'm dr. Frank summers of the Space

2
00:00:10,820 --> 00:00:07,710
Telescope Science Institute and welcome

3
00:00:13,190 --> 00:00:10,830
to the Hubble national teachin first

4
00:00:15,230 --> 00:00:13,200
we've got a very special guest NASA

5
00:00:18,099 --> 00:00:15,240
Administrator Charles Bolden who wants

6
00:00:20,779 --> 00:00:18,109
to give you his own personal welcome

7
00:00:23,000 --> 00:00:20,789
thank you to all the educators students

8
00:00:25,370 --> 00:00:23,010
scientists and engineers participating

9
00:00:27,650 --> 00:00:25,380
in today's Hubble teach-in when we

10
00:00:30,349 --> 00:00:27,660
launch this magnificent telescope 25

11
00:00:32,690 --> 00:00:30,359
years ago today we knew it would be

12
00:00:34,700 --> 00:00:32,700
special but we really had no idea the

13
00:00:36,260 --> 00:00:34,710

degree to which it would transform our

14
00:00:39,740 --> 00:00:36,270
understanding of the universe and

15
00:00:42,200 --> 00:00:39,750
rewrite textbooks today the Hubble Space

16
00:00:44,779 --> 00:00:42,210
Telescope continues to provide more data

17
00:00:47,750 --> 00:00:44,789
each year than there is in the entire

18
00:00:49,520 --> 00:00:47,760
library of congress it's confirmed the

19
00:00:51,740 --> 00:00:49,530
presence of black holes in the Centers

20
00:00:53,840 --> 00:00:51,750
of the galaxies it made the first

21
00:00:55,310 --> 00:00:53,850
observations of the chemical makeup of

22
00:00:57,830 --> 00:00:55,320
the atmosphere of a planet orbiting

23
00:01:00,380 --> 00:00:57,840
another star it helped scientists

24
00:01:03,500 --> 00:01:00,390
determine that the cosmos is 13.7

25
00:01:06,230 --> 00:01:03,510
billion years old it provided the first

26
00:01:08,420 --> 00:01:06,240
high-resolution maps of the structures

27
00:01:11,719 --> 00:01:08,430
of planet-forming discs around stars

28
00:01:15,230 --> 00:01:11,729
like our Sun and those are just a few of

29
00:01:16,969 --> 00:01:15,240
Hubble's greatest hits it was my great

30
00:01:19,550 --> 00:01:16,979
pleasure to be a part of the crew that

31
00:01:22,010 --> 00:01:19,560
brought Hubble to space many astronauts

32
00:01:23,870 --> 00:01:22,020
cents have helped repair it and keep it

33
00:01:26,600 --> 00:01:23,880
running and many talented and dedicated

34
00:01:28,730 --> 00:01:26,610
folks on the ground have continued to

35
00:01:31,340 --> 00:01:28,740
monitor and manage this magnificent

36
00:01:34,010 --> 00:01:31,350
one-of-a-kind telescope there are nearly

37
00:01:36,200 --> 00:01:34,020
endless possibilities for learning from

38
00:01:39,109 --> 00:01:36,210

the wonderful data and images that

39
00:01:41,569 --> 00:01:39,119
Hubble continues to send us I applaud

40
00:01:43,190 --> 00:01:41,579
the teachin for helping to inspire the

41
00:01:46,219 --> 00:01:43,200
next generation of scientists and

42
00:01:48,910 --> 00:01:46,229
engineers who may someday work on their

43
00:01:51,350 --> 00:01:48,920
own great observatory and once again

44
00:01:54,020 --> 00:01:51,360
transform humanity's understanding of

45
00:01:56,420 --> 00:01:54,030
our place in the universe I hope you

46
00:01:58,399 --> 00:01:56,430
learn a lot today I also hope your

47
00:02:00,620 --> 00:01:58,409
journey with Hubble the James Webb Space

48
00:02:03,770 --> 00:02:00,630
Telescope that launches in just a few

49
00:02:06,139 --> 00:02:03,780
years and all of NASA's missions will

50
00:02:15,400 --> 00:02:06,149
continue to inspire you and help you

51
00:02:20,860 --> 00:02:18,910
it's a public outreach here at stsci in

52
00:02:23,080 --> 00:02:20,870
particular I want to give you a welcome

53
00:02:25,180 --> 00:02:23,090
from Bonnie aizen hammer our education

54
00:02:27,850 --> 00:02:25,190
program manager she's the one on the

55
00:02:30,310 --> 00:02:27,860
right in this image Bonnie and I work

56
00:02:32,950 --> 00:02:30,320
very close together we believe in the

57
00:02:35,200 --> 00:02:32,960
scientist educator partnership which is

58
00:02:37,870 --> 00:02:35,210
what makes our education program so

59
00:02:39,490 --> 00:02:37,880
special we also have a lot of other

60
00:02:41,950 --> 00:02:39,500
folks here at the Space Telescope

61
00:02:44,200 --> 00:02:41,960
Science Institute this is one of our

62
00:02:46,390 --> 00:02:44,210
group photographs we've taken when the

63
00:02:48,360 --> 00:02:46,400

astronauts come to visit you can see

64
00:02:50,950 --> 00:02:48,370
that there are a lot of folks here and

65
00:02:53,320 --> 00:02:50,960
it includes the people that you might

66
00:02:56,110 --> 00:02:53,330
normally expect the astronomers the

67
00:02:57,430 --> 00:02:56,120
engineers the computer programmers it

68
00:02:59,590 --> 00:02:57,440
also includes the people that you would

69
00:03:02,590 --> 00:02:59,600
you need to run a business those who

70
00:03:04,750 --> 00:03:02,600
work in finance personnel maintenance

71
00:03:08,260 --> 00:03:04,760
but it also includes some people you

72
00:03:11,230 --> 00:03:08,270
might not expect like writers artists

73
00:03:13,240 --> 00:03:11,240
and teachers these are the people that

74
00:03:16,360 --> 00:03:13,250
helped us get Hubble's discoveries out

75
00:03:19,630 --> 00:03:16,370
to the public and out into our education

76
00:03:22,870 --> 00:03:19,640
and I think it for us it teaches a

77
00:03:25,990 --> 00:03:22,880
lesson that you don't have to be a PhD

78
00:03:29,140 --> 00:03:26,000
astrophysics geek to work on Hubble we

79
00:03:31,600 --> 00:03:29,150
have about 500 people here who all are

80
00:03:34,210 --> 00:03:31,610
very proud to a good part of the Hubble

81
00:03:38,140 --> 00:03:34,220
program so no matter what you do in your

82
00:03:40,180 --> 00:03:38,150
career you can be an artist and still be

83
00:03:43,840 --> 00:03:40,190
involved in science I'm an astronomer

84
00:03:46,030 --> 00:03:43,850
but I've worked on three IMAX films so

85
00:03:47,949 --> 00:03:46,040
really you don't need to limit yourself

86
00:03:50,040 --> 00:03:47,959
in your career and we embody that here

87
00:03:53,949 --> 00:03:50,050
at the Space Telescope Science Institute

88
00:03:56,380 --> 00:03:53,959

so let's talk about how Hubble is a

89
00:04:00,160 --> 00:03:56,390
Space Telescope spaces its middle name

90
00:04:03,940 --> 00:04:00,170
and here is an image of Earth and it's

91
00:04:06,820 --> 00:04:03,950
not that far out into space here is a

92
00:04:10,060 --> 00:04:06,830
diagram showing you the size of Hubble's

93
00:04:12,390 --> 00:04:10,070
orbit relative to the size of Earth how

94
00:04:16,110 --> 00:04:12,400
about is what we call low Earth orbit

95
00:04:18,539 --> 00:04:16,120
it's just up above Earth's atmosphere

96
00:04:21,190 --> 00:04:18,549
here's an image that illustrates that

97
00:04:23,200 --> 00:04:21,200
Hubble is just above Earth's atmosphere

98
00:04:25,870 --> 00:04:23,210
and if you look you can see that fuzzy

99
00:04:27,350 --> 00:04:25,880
edge to Earth's atmosphere that is

100
00:04:30,050 --> 00:04:27,360
Hubble's main

101
00:04:33,020 --> 00:04:30,060
advantage by getting up above Earth's

102
00:04:36,529 --> 00:04:33,030
atmosphere Hubble gets the clearest view

103
00:04:38,300 --> 00:04:36,539
of any visible light telescope now when

104
00:04:40,640 --> 00:04:38,310
we were young we all learned about

105
00:04:43,339 --> 00:04:40,650
twinkle twinkle little star well that

106
00:04:45,589 --> 00:04:43,349
twinkle is caused by Earth's atmosphere

107
00:04:48,230 --> 00:04:45,599
so it is the process of getting above

108
00:04:52,999 --> 00:04:48,240
Earth's atmosphere that gives Hubble

109
00:04:54,589 --> 00:04:53,009
it's amazing you'd now you don't need to

110
00:04:56,779 --> 00:04:54,599
read all this slide this is just some

111
00:04:59,689 --> 00:04:56,789
facts about Hubble but you might want to

112
00:05:01,820 --> 00:04:59,699
know its size its length is about 43

113
00:05:04,519 --> 00:05:01,830

feet and that's the size of a large

114
00:05:06,290 --> 00:05:04,529
school bus I like to sort of joke that

115
00:05:08,330 --> 00:05:06,300
if ms frizzle and the Magic School Bus

116
00:05:10,969 --> 00:05:08,340
would not to visit Hubble it'd be about

117
00:05:12,709 --> 00:05:10,979
the same size of course those of you

118
00:05:14,209 --> 00:05:12,719
who've read the books recognize that ms

119
00:05:15,709 --> 00:05:14,219
frizzle drives a shorter school bus

120
00:05:17,510 --> 00:05:15,719
she'd have to drag one of the big long

121
00:05:20,269 --> 00:05:17,520
school buses and then it would be about

122
00:05:22,450 --> 00:05:20,279
the same size as Howell the other thing

123
00:05:25,339 --> 00:05:22,460
to note is that Hubble is moving at

124
00:05:28,279 --> 00:05:25,349
17,000 about 17,000 miles an hour and

125
00:05:31,249 --> 00:05:28,289
makes one orbit about an an hour and a

126
00:05:33,769 --> 00:05:31,259
half so while we're doing this teaching

127
00:05:35,209 --> 00:05:33,779
for about an hour Hubble will travel

128
00:05:40,279 --> 00:05:35,219
around two thirds of the way around

129
00:05:44,950 --> 00:05:40,289
Earth the hubble space telescope was

130
00:05:46,850 --> 00:05:44,960
launched in 1990 25 years ago today and

131
00:05:50,269 --> 00:05:46,860
do you know what NASA Administrator

132
00:05:53,689 --> 00:05:50,279
Charles Bolden was doing then he was on

133
00:05:56,990 --> 00:05:53,699
the astronaut team that put Hubble into

134
00:06:00,249 --> 00:05:57,000
orbit and here is a marvelous photograph

135
00:06:04,850 --> 00:06:00,259
of home being set into orbit from the

136
00:06:07,070 --> 00:06:04,860
Bay of the space shuttle now 25 years

137
00:06:08,959 --> 00:06:07,080
ago is a really long time matter of fact

138
00:06:11,209 --> 00:06:08,969

for all the kids that are in elementary

139
00:06:14,959 --> 00:06:11,219
school and middle school and high school

140
00:06:17,089 --> 00:06:14,969
and even college 25 years is longer than

141
00:06:19,909 --> 00:06:17,099
they've been alive Hubble was launched

142
00:06:23,029 --> 00:06:19,919
before you were born you've never known

143
00:06:25,429 --> 00:06:23,039
a world without Hubble so let's try and

144
00:06:28,550 --> 00:06:25,439
do Oh an idea of what it was like way

145
00:06:30,679 --> 00:06:28,560
back in nineteen ninety so this is an

146
00:06:34,429 --> 00:06:30,689
image of a computer that's very much

147
00:06:37,339 --> 00:06:34,439
like the one I had in 1994 the adults

148
00:06:39,740 --> 00:06:37,349
it's like a 386 with a cd-rom drive and

149
00:06:42,950 --> 00:06:39,750
a three-and-a-half inch floppy disk

150
00:06:45,470 --> 00:06:42,960
now I have a computer that's thousand

151
00:06:52,010 --> 00:06:45,480
times faster and has a thousand times

152
00:06:55,880 --> 00:06:52,020
more memory and it fits in my pocket my

153
00:06:58,220 --> 00:06:55,890
cell phone that i carry today is times

154
00:07:01,610 --> 00:06:58,230
better in every way then the computer i

155
00:07:03,740 --> 00:07:01,620
had in 1990 and it's probably a million

156
00:07:06,500 --> 00:07:03,750
times more useful because of all the

157
00:07:08,780 --> 00:07:06,510
software that's written for it now

158
00:07:11,360 --> 00:07:08,790
because of that because it was so long

159
00:07:13,270 --> 00:07:11,370
ago in technical technology time people

160
00:07:16,760 --> 00:07:13,280
may think that Hubble is old technology

161
00:07:18,680 --> 00:07:16,770
well how do we keep it current the

162
00:07:20,840 --> 00:07:18,690
astronauts who put Hubble until it not

163
00:07:23,720 --> 00:07:20,850

only put Hubble into orbit they also

164
00:07:25,730 --> 00:07:23,730
went up and had five servicing missions

165
00:07:27,650 --> 00:07:25,740
to help here are pictures of the

166
00:07:29,930 --> 00:07:27,660
astronauts and some pictures of them

167
00:07:32,420 --> 00:07:29,940
servicing Kabul and during those five

168
00:07:34,850 --> 00:07:32,430
servicing missions like that old

169
00:07:37,580 --> 00:07:34,860
computer which I was able to upgrade the

170
00:07:40,130 --> 00:07:37,590
processor and upgrade the RAM and go

171
00:07:42,409 --> 00:07:40,140
from a cd-rom drive to a dvd-rom drive

172
00:07:44,600 --> 00:07:42,419
we've been able to do that with Hubble

173
00:07:46,940 --> 00:07:44,610
we've been able to take out the old

174
00:07:49,790 --> 00:07:46,950
instruments put in new instruments

175
00:07:52,820 --> 00:07:49,800
upgrade it repair it and as NASA likes

176
00:07:55,909 --> 00:07:52,830
to say repair refresh and renew Hubble

177
00:07:59,300 --> 00:07:55,919
with each visit so Hubble isn't old

178
00:08:01,820 --> 00:07:59,310
technology how well as is 25 years old

179
00:08:03,770 --> 00:08:01,830
since it was launched but it is filled

180
00:08:06,290 --> 00:08:03,780
with a lot of brand new technology and

181
00:08:09,080 --> 00:08:06,300
I'll show you the roles of that now it

182
00:08:11,750 --> 00:08:09,090
was really great that Hubble was able to

183
00:08:13,460 --> 00:08:11,760
be serviced because and you don't

184
00:08:15,440 --> 00:08:13,470
remember this again this had probably

185
00:08:17,570 --> 00:08:15,450
happened before you were born but when

186
00:08:20,270 --> 00:08:17,580
Hubble was originally launched it had a

187
00:08:22,520 --> 00:08:20,280
flaw in the mirror the mirror was ground

188
00:08:26,570 --> 00:08:22,530

to a very exact shape but it was just

189
00:08:28,450 --> 00:08:26,580
slightly out of focus so on the left you

190
00:08:32,300 --> 00:08:28,460
see the image of the center of a galaxy

191
00:08:35,329 --> 00:08:32,310
before the repair in 1993 servicing

192
00:08:37,339 --> 00:08:35,339
mission 11 went up and repaired the flaw

193
00:08:39,560 --> 00:08:37,349
on Hubble's mirror it fit on well it's

194
00:08:42,110 --> 00:08:39,570
could put on my glasses on Hubble so

195
00:08:44,690 --> 00:08:42,120
that it could correct the wave front so

196
00:08:46,880 --> 00:08:44,700
that Hubble could see clearly on the

197
00:08:49,130 --> 00:08:46,890
right you see the result after the

198
00:08:52,490 --> 00:08:49,140
repair and you can see the clarity with

199
00:08:53,319 --> 00:08:52,500
which Hubble sees the universe now

200
00:08:54,759 --> 00:08:53,329
that's not

201
00:08:57,609 --> 00:08:54,769
say that before the repair Hubble was

202
00:08:59,289 --> 00:08:57,619
useless how will still had better

203
00:09:01,449 --> 00:08:59,299
resolution than any ground-based

204
00:09:03,999 --> 00:09:01,459
telescope before the repair and could

205
00:09:07,059 --> 00:09:04,009
still do science that could not be done

206
00:09:09,220 --> 00:09:07,069
from the ground however it was after the

207
00:09:10,809 --> 00:09:09,230
repair missions that Hubble was finally

208
00:09:13,179 --> 00:09:10,819
able to achieve its design

209
00:09:16,509 --> 00:09:13,189
specifications and do all the great

210
00:09:18,160 --> 00:09:16,519
science that we intended it for so let's

211
00:09:19,989 --> 00:09:18,170
talk about some of that science and will

212
00:09:23,259 --> 00:09:19,999
begin in our solar system with the

213
00:09:26,049 --> 00:09:23,269

planet Jupiter this is Jupiter the

214
00:09:28,449 --> 00:09:26,059
largest of the planets and it has a

215
00:09:30,549 --> 00:09:28,459
wonderful feature called the Great Red

216
00:09:33,609 --> 00:09:30,559
Spot you can see it down there just

217
00:09:35,530 --> 00:09:33,619
below the equator and i zoom in on it

218
00:09:37,030 --> 00:09:35,540
well this is an assume and this is a

219
00:09:38,799 --> 00:09:37,040
picture from the Voyager mission that

220
00:09:40,660 --> 00:09:38,809
went past it it's one of my favorite

221
00:09:42,579 --> 00:09:40,670
pictures in astronomy there so many of

222
00:09:45,189 --> 00:09:42,589
those but you can see the Great Red Spot

223
00:09:47,669 --> 00:09:45,199
and you can also see those white ovals

224
00:09:51,669 --> 00:09:47,679
those large white ovals these are all

225
00:09:54,160 --> 00:09:51,679
storms in Jupiter's atmosphere jupiter

226
00:09:56,289 --> 00:09:54,170
has a lot of storms and those white

227
00:09:58,629 --> 00:09:56,299
ovals are storms like our giant

228
00:10:01,179 --> 00:09:58,639
hurricanes and the Great Red Spot is the

229
00:10:04,809 --> 00:10:01,189
granddaddy of them all it's the largest

230
00:10:07,749 --> 00:10:04,819
of the storms on Jupiter how large is it

231
00:10:13,059 --> 00:10:07,759
well here is a comparison of the Great

232
00:10:16,379 --> 00:10:13,069
Red Spot to our entire planet on Jupiter

233
00:10:21,549 --> 00:10:16,389
they have a storm larger than our entire

234
00:10:25,479 --> 00:10:21,559
planet that's big and not only is it big

235
00:10:29,049 --> 00:10:25,489
but it's also long lasting Hubble has

236
00:10:31,919 --> 00:10:29,059
been up for 25 years and has studied the

237
00:10:35,289 --> 00:10:31,929
Great Red Spot for the entire 25 years

238
00:10:37,809 --> 00:10:35,299

but the Great Red Spot has been around

239
00:10:40,780 --> 00:10:37,819
for as long as we know we have

240
00:10:43,359 --> 00:10:40,790
observations from 200 years ago showing

241
00:10:46,449 --> 00:10:43,369
the Great Red Spot and we may even have

242
00:10:49,659 --> 00:10:46,459
observations from 350 years ago showing

243
00:10:54,220 --> 00:10:49,669
the red spot so it's a giant storm at

244
00:10:56,829 --> 00:10:54,230
last for centuries now during Hubble's

245
00:11:00,460 --> 00:10:56,839
time watching it Hubble has actually

246
00:11:02,999 --> 00:11:00,470
seen the Great Red Spot shrink you can

247
00:11:06,159 --> 00:11:03,009
see in the top image the Great Red Spot

248
00:11:06,980 --> 00:11:06,169
1995 was significantly larger than it is

249
00:11:10,940 --> 00:11:06,990
in the bottom

250
00:11:13,190 --> 00:11:10,950
image the Great Red Spot in 2014 we've

251
00:11:15,199 --> 00:11:13,200
actually seen the grid rate that red

252
00:11:19,130 --> 00:11:15,209
spots to shrink over the time Hubble has

253
00:11:22,400 --> 00:11:19,140
been up why well I got to be honest with

254
00:11:24,260 --> 00:11:22,410
you we're not exactly sure it's a topic

255
00:11:26,660 --> 00:11:24,270
of current research trying to find out

256
00:11:29,050 --> 00:11:26,670
why the Great Red Spot is very slowly

257
00:11:33,440 --> 00:11:29,060
shrinking over these past few decades

258
00:11:36,380 --> 00:11:33,450
but there's more for red spots because

259
00:11:38,540 --> 00:11:36,390
in 1997 three of those white ovals that

260
00:11:41,750 --> 00:11:38,550
I mentioned earlier started to merge

261
00:11:46,940 --> 00:11:41,760
together and in 1998 two of them merged

262
00:11:48,620 --> 00:11:46,950
and in 2003 all words together to form

263
00:11:52,610 --> 00:11:48,630

an oval that well I guess it's called

264
00:11:55,449 --> 00:11:52,620
oval VA and that was the largest storm

265
00:12:01,970 --> 00:11:55,459
outside of the Great Red Spot on Jupiter

266
00:12:05,000 --> 00:12:01,980
but in 2006 that ol turned red and for

267
00:12:09,350 --> 00:12:05,010
the first time ever we saw the formation

268
00:12:11,210 --> 00:12:09,360
of a red spot now again it's called oval

269
00:12:15,019 --> 00:12:11,220
ba but we gave it the colloquial name

270
00:12:17,360 --> 00:12:15,029
red spot junior and red spot junior has

271
00:12:19,130 --> 00:12:17,370
also proven to be a long-lived storm and

272
00:12:25,670 --> 00:12:19,140
it is still there in Jupiter's

273
00:12:28,970 --> 00:12:25,680
atmosphere plus in 2008 we saw the

274
00:12:31,519 --> 00:12:28,980
appearance of a third red spot so you've

275
00:12:34,250 --> 00:12:31,529
got the great red spot on the right red

276
00:12:36,410 --> 00:12:34,260
spot Junior down lower left and in the

277
00:12:39,650 --> 00:12:36,420
middle on the left we have what we hope

278
00:12:41,180 --> 00:12:39,660
we have called baby red spot but you can

279
00:12:43,790 --> 00:12:41,190
see that red spot Junior is at a

280
00:12:45,949 --> 00:12:43,800
different latitude from the Great Red

281
00:12:48,850 --> 00:12:45,959
Spot it is passed by the Great Red Spot

282
00:12:51,590 --> 00:12:48,860
several times and everything's fine

283
00:12:54,139 --> 00:12:51,600
unfortunately the baby red spot was at

284
00:12:57,590 --> 00:12:54,149
the same latitude and so we watched over

285
00:13:00,230 --> 00:12:57,600
the summer of 2008 as it approached and

286
00:13:04,100 --> 00:13:00,240
then got caught into the vortices of the

287
00:13:06,110 --> 00:13:04,110
Great Red Spot and dissipated away so

288
00:13:08,420 --> 00:13:06,120

with Hubble we've been able to study the

289
00:13:10,970 --> 00:13:08,430
Great Red Spot over decades we've seen

290
00:13:12,949 --> 00:13:10,980
the formation of red spot jr. and we've

291
00:13:15,800 --> 00:13:12,959
seen the dissolution of the baby red

292
00:13:17,930 --> 00:13:15,810
spot now next time you think that the

293
00:13:19,220 --> 00:13:17,940
door weather is really horrible just

294
00:13:20,600 --> 00:13:19,230
remember the storms here on earth

295
00:13:24,530 --> 00:13:20,610
they're nothing

296
00:13:27,350 --> 00:13:24,540
compared to what we have on Jupiter so

297
00:13:29,900 --> 00:13:27,360
let's move on the go up a scale to stars

298
00:13:31,870 --> 00:13:29,910
and what we show here is the

299
00:13:35,000 --> 00:13:31,880
constellation of Orion and the

300
00:13:37,519 --> 00:13:35,010
upper-left star is the star called fatal

301
00:13:39,920 --> 00:13:37,529
juice now what you need to remember

302
00:13:43,069 --> 00:13:39,930
about stars is that they're really

303
00:13:46,340 --> 00:13:43,079
really far away so when we look at a

304
00:13:49,519 --> 00:13:46,350
star it's just a point of light the size

305
00:13:52,220 --> 00:13:49,529
of a star compared to its distance is so

306
00:13:56,470 --> 00:13:52,230
great that even with the best telescopes

307
00:13:59,900 --> 00:13:56,480
stars or desk points of light except

308
00:14:03,590 --> 00:13:59,910
Hubble with its exquisite resolution was

309
00:14:05,540 --> 00:14:03,600
able to resolve the star Betelgeuse it

310
00:14:07,880 --> 00:14:05,550
was able to measure several pixels

311
00:14:10,670 --> 00:14:07,890
across the face of bailed it's the first

312
00:14:13,850 --> 00:14:10,680
time an optical telescope had been able

313
00:14:16,730 --> 00:14:13,860

to resolve a star now you might say wow

314
00:14:19,880 --> 00:14:16,740
Hubble is just so amazing well it's also

315
00:14:23,120 --> 00:14:19,890
that baitul juice is so amazing because

316
00:14:26,300 --> 00:14:23,130
baitul juice is a red supergiant star

317
00:14:29,389 --> 00:14:26,310
and you can see by the scale bars but

318
00:14:31,850 --> 00:14:29,399
beneath it that baitul juice is not only

319
00:14:35,120 --> 00:14:31,860
larger than Earth's orbit it's larger

320
00:14:36,530 --> 00:14:35,130
than Jupiter's orbit around the Sun so

321
00:14:41,360 --> 00:14:36,540
if baitul juice were in the place of our

322
00:14:44,689 --> 00:14:41,370
Sun Mercury Venus Earth Mars and Jupiter

323
00:14:49,040 --> 00:14:44,699
would all be orbiting inside of baitul

324
00:14:51,290 --> 00:14:49,050
juice another great use of Hubble four

325
00:14:53,870 --> 00:14:51,300
stars has been to look at star clusters

326
00:14:56,780 --> 00:14:53,880
and this is this globular cluster

327
00:14:59,509 --> 00:14:56,790
Messier 80 and these are these really

328
00:15:01,790 --> 00:14:59,519
dense stellar systems stars that formed

329
00:15:04,160 --> 00:15:01,800
all together and are orbiting around one

330
00:15:07,400 --> 00:15:04,170
another and Hubble's exquisite

331
00:15:08,960 --> 00:15:07,410
resolution is especially good in looking

332
00:15:11,439 --> 00:15:08,970
toward the course of these globular

333
00:15:14,870 --> 00:15:11,449
clusters and being able to resolve the

334
00:15:17,540 --> 00:15:14,880
individual stars and see the details of

335
00:15:21,530 --> 00:15:17,550
their characteristics and their motions

336
00:15:23,900 --> 00:15:21,540
within these globular clusters also

337
00:15:26,689 --> 00:15:23,910
Hubble being above Earth's atmosphere

338
00:15:29,350 --> 00:15:26,699

can look in the ultraviolet at the

339
00:15:33,070 --> 00:15:29,360
visible and a little bit of the infrared

340
00:15:36,220 --> 00:15:33,080
so this image here with it's bright red

341
00:15:38,920 --> 00:15:36,230
bright blue colors is actually showing

342
00:15:42,370 --> 00:15:38,930
you a multi-wavelength view of the

343
00:15:45,010 --> 00:15:42,380
interior of a globular cluster the blue

344
00:15:48,090 --> 00:15:45,020
in this image is ultraviolet light and

345
00:15:50,620 --> 00:15:48,100
the red in this image is infrared light

346
00:15:52,660 --> 00:15:50,630
this shows that Hubble has been able to

347
00:15:55,750 --> 00:15:52,670
look a multi-wavelength from ultraviolet

348
00:15:58,600 --> 00:15:55,760
to visible to infrared inside this

349
00:16:02,320 --> 00:15:58,610
globular cluster it also allows Hubble

350
00:16:04,900 --> 00:16:02,330
to capture the very rare objects within

351
00:16:07,480 --> 00:16:04,910
the globular cluster for example stars

352
00:16:09,160 --> 00:16:07,490
and collided together and merged these

353
00:16:11,860 --> 00:16:09,170
stellar collisions that occur only

354
00:16:13,870 --> 00:16:11,870
inside globular clusters create blue

355
00:16:16,540 --> 00:16:13,880
stars that radiate in the ultraviolet or

356
00:16:17,830 --> 00:16:16,550
the old stars like baitul juice the ones

357
00:16:20,200 --> 00:16:17,840
that are becoming red giants and

358
00:16:23,470 --> 00:16:20,210
supergiant's they will radiate a lot in

359
00:16:25,600 --> 00:16:23,480
the infrared and show up in the red so

360
00:16:28,630 --> 00:16:25,610
Hubble has been very very valuable in

361
00:16:31,540 --> 00:16:28,640
the study of these dense stellar systems

362
00:16:35,590 --> 00:16:31,550
and see how stars move and act in their

363
00:16:39,100 --> 00:16:35,600

characteristics inside star clusters now

364
00:16:42,340 --> 00:16:39,110
star clusters are also very associated

365
00:16:45,820 --> 00:16:42,350
with nebula matter of fact stars form in

366
00:16:47,770 --> 00:16:45,830
clusters inside nebula and this image

367
00:16:50,350 --> 00:16:47,780
here is one that we released yesterday

368
00:16:52,600 --> 00:16:50,360
for Hubble's 25th anniversary

369
00:16:56,560 --> 00:16:52,610
re-released an image of the star cluster

370
00:16:58,840 --> 00:16:56,570
Westerlund to inside the nebula gum 29

371
00:17:00,340 --> 00:16:58,850
and this is an image you may have seen

372
00:17:02,050 --> 00:17:00,350
on the internet in the last 24 hours

373
00:17:04,900 --> 00:17:02,060
because it's gotten quite a lot of

374
00:17:06,939 --> 00:17:04,910
attention we also made a

375
00:17:09,130 --> 00:17:06,949
three-dimensional visualization of this

376
00:17:11,680 --> 00:17:09,140
where we get to fly in to take a look at

377
00:17:14,079 --> 00:17:11,690
that star cluster now I can't show you

378
00:17:15,760 --> 00:17:14,089
the movies on this hangout but I can

379
00:17:19,030 --> 00:17:15,770
give you a few frames of it to give the

380
00:17:23,290 --> 00:17:19,040
ax feeling of it so the camera flies

381
00:17:25,630 --> 00:17:23,300
into the the nebula gum 29 and as we

382
00:17:29,290 --> 00:17:25,640
zoom in the stars come past the camera

383
00:17:31,570 --> 00:17:29,300
and the camera descends onto the edge of

384
00:17:34,720 --> 00:17:31,580
the nebula the nebula gum 29 onto the

385
00:17:37,390 --> 00:17:34,730
lower rim of it then it starts to pass

386
00:17:39,460 --> 00:17:37,400
by a little valves of gas that's on the

387
00:17:42,310 --> 00:17:39,470
near edge of it and starts to penetrate

388
00:17:44,410 --> 00:17:42,320

into the heart of the nebula we five

389
00:17:45,340 --> 00:17:44,420
past all those pillars these pillars

390
00:17:47,350 --> 00:17:45,350
would get a dark

391
00:17:48,909 --> 00:17:47,360
acid us that are pointed toward the

392
00:17:51,669 --> 00:17:48,919
cluster because they're actually being

393
00:17:54,159 --> 00:17:51,679
shaped by the cluster the winds and

394
00:17:56,890 --> 00:17:54,169
radiation are shaping them and finally

395
00:17:59,520 --> 00:17:56,900
we zoom in to see the details the

396
00:18:04,360 --> 00:17:59,530
thousands of stars inside the cluster

397
00:18:07,600 --> 00:18:04,370
Westerlund to this is a wonderful way to

398
00:18:09,520 --> 00:18:07,610
experience it and it is our way of

399
00:18:11,799 --> 00:18:09,530
reminding you that these two-dimensional

400
00:18:13,630 --> 00:18:11,809
images from Hubble are really

401
00:18:17,590 --> 00:18:13,640
representations of a three-dimensional

402
00:18:20,049 --> 00:18:17,600
universe now this is a great segue into

403
00:18:22,390 --> 00:18:20,059
talking about nebula and a particular

404
00:18:24,279 --> 00:18:22,400
star cluster star formation of street as

405
00:18:27,640 --> 00:18:24,289
we a particular star formation region

406
00:18:30,700 --> 00:18:27,650
called the Orion Nebula the Orion Nebula

407
00:18:33,220 --> 00:18:30,710
is one of the nearest large star forming

408
00:18:35,770 --> 00:18:33,230
regions it has all sorts of activity

409
00:18:38,860 --> 00:18:35,780
going on in it and this image from 2006

410
00:18:41,740 --> 00:18:38,870
is incredibly detailed but actually I'm

411
00:18:45,669 --> 00:18:41,750
going to go back to an image from 1995

412
00:18:48,159 --> 00:18:45,679
which takes the center of the Orion

413
00:18:51,100 --> 00:18:48,169

Nebula and brings that out in sharp

414
00:18:53,890 --> 00:18:51,110
relief in the center there are four

415
00:18:56,289 --> 00:18:53,900
large stars called the trapezium and it

416
00:18:58,600 --> 00:18:56,299
is these stars that have the strong

417
00:19:01,960 --> 00:18:58,610
stellar winds and the intense

418
00:19:04,659 --> 00:19:01,970
ultraviolet emission that caused the gas

419
00:19:08,080 --> 00:19:04,669
around it to glow and also shape the

420
00:19:10,870 --> 00:19:08,090
objects around it for example on the

421
00:19:13,630 --> 00:19:10,880
right in this image is a star called ll

422
00:19:16,029 --> 00:19:13,640
Oriana's and the winds from these hot

423
00:19:18,970 --> 00:19:16,039
stars in the center are sweeping past

424
00:19:21,760 --> 00:19:18,980
llo Oriana's and you can see a bow shock

425
00:19:23,950 --> 00:19:21,770
in on its near side a battle shock like

426
00:19:25,960 --> 00:19:23,960
a boat going across a call motion

427
00:19:28,360 --> 00:19:25,970
creates a bow shock in front of it it's

428
00:19:31,029 --> 00:19:28,370
the same thing here but now it's the

429
00:19:35,140 --> 00:19:31,039
winds from these stars sweeping past the

430
00:19:38,020 --> 00:19:35,150
gas around ll orianna's the upper left I

431
00:19:40,390 --> 00:19:38,030
show you a star that's forming much

432
00:19:43,090 --> 00:19:40,400
nearer to the central cluster and

433
00:19:45,399 --> 00:19:43,100
instead of just creating a nice soft bow

434
00:19:50,140 --> 00:19:45,409
shock that bow shock has wrapped around

435
00:19:53,409 --> 00:19:50,150
to form a windsock type type shape we

436
00:19:55,510 --> 00:19:53,419
call these tadpoles or actually

437
00:19:57,900 --> 00:19:55,520
astronomers given the name Pro pleads

438
00:19:59,910 --> 00:19:57,910

for protoplanetary discs

439
00:20:02,850 --> 00:19:59,920
what's happened is the wind is so strong

440
00:20:06,810 --> 00:20:02,860
it is wrapped the gas around it and you

441
00:20:09,300 --> 00:20:06,820
get that win sought type shape finally

442
00:20:12,330 --> 00:20:09,310
down bottom you can see an image of a

443
00:20:17,520 --> 00:20:12,340
newborn star and you can see a black

444
00:20:21,240 --> 00:20:17,530
area around it that black area is a disk

445
00:20:25,980 --> 00:20:21,250
of material and inside that disk of

446
00:20:30,930 --> 00:20:25,990
material planets will be forming in the

447
00:20:34,440 --> 00:20:30,940
Orion Nebula we have now seen solar

448
00:20:37,140 --> 00:20:34,450
systems in formation that star is born

449
00:20:39,600 --> 00:20:37,150
and as that stars form you form a disk

450
00:20:42,990 --> 00:20:39,610
of material around it and in that disk

451
00:20:47,100 --> 00:20:43,000
you get planets we can see planetary

452
00:20:49,800 --> 00:20:47,110
systems in formation in Iranian an Orion

453
00:20:53,190 --> 00:20:49,810
is very special to me because the IMAX

454
00:20:55,620 --> 00:20:53,200
film hubble 3d we did a full fledged 3d

455
00:20:59,390 --> 00:20:55,630
visualization of Orion and I want to let

456
00:21:01,680 --> 00:20:59,400
you know that the imax company has

457
00:21:03,930 --> 00:21:01,690
re-released imax hubble 3d in

458
00:21:06,240 --> 00:21:03,940
celebration of Hubble's 25th anniversary

459
00:21:08,220 --> 00:21:06,250
so if you're looking for a way to get

460
00:21:09,630 --> 00:21:08,230
more Hubble this weekend go out and

461
00:21:11,670 --> 00:21:09,640
check and see if your outlook imax

462
00:21:16,170 --> 00:21:11,680
theatre is playing imax hubble this

463
00:21:19,440 --> 00:21:16,180

weekend let's the move on up to galaxies

464
00:21:21,570 --> 00:21:19,450
and again i have so many favorite images

465
00:21:24,390 --> 00:21:21,580
in astronomy this is definitely one of

466
00:21:26,640 --> 00:21:24,400
them the Whirlpool Galaxy it's the

467
00:21:29,190 --> 00:21:26,650
classic spiral galaxy you can see those

468
00:21:32,280 --> 00:21:29,200
beautiful pinwheel shape of those spiral

469
00:21:34,800 --> 00:21:32,290
arms now to get a sense of scale for

470
00:21:38,730 --> 00:21:34,810
this galaxy do you see all those pink

471
00:21:41,760 --> 00:21:38,740
dots along the spiral arms those pink

472
00:21:45,150 --> 00:21:41,770
regions are star forming regions like

473
00:21:46,770 --> 00:21:45,160
the Orion Nebula every single one that

474
00:21:49,680 --> 00:21:46,780
affect Orion would probably be a pretty

475
00:21:51,990 --> 00:21:49,690
small one of those pink dots all of

476
00:21:54,510 --> 00:21:52,000
those pink dots are places where

477
00:21:56,640 --> 00:21:54,520
thousands of stars are being born and

478
00:21:59,550 --> 00:21:56,650
that gives you a scale that you know

479
00:22:03,450 --> 00:21:59,560
there are hundreds of billions of stars

480
00:22:07,080 --> 00:22:03,460
in this galaxy now spiral galaxies can

481
00:22:09,150 --> 00:22:07,090
also look like this one here because

482
00:22:11,830 --> 00:22:09,160
spiral galaxies are actually pancake

483
00:22:14,260 --> 00:22:11,840
shape you see the spiral arms

484
00:22:16,390 --> 00:22:14,270
you look at the pancake face on but when

485
00:22:20,200 --> 00:22:16,400
you look at it edge on you see that dark

486
00:22:23,620 --> 00:22:20,210
disk of material other galaxies shapes

487
00:22:26,230 --> 00:22:23,630
include a barred spiral shape in which

488
00:22:28,720 --> 00:22:26,240

you've got a very long bar as well as

489
00:22:32,470 --> 00:22:28,730
the spiral arms the spiral arms come off

490
00:22:34,120 --> 00:22:32,480
of the long bar in the center if you

491
00:22:36,789 --> 00:22:34,130
just take that central region which is

492
00:22:40,029 --> 00:22:36,799
sort of you know fluffy shaped you get a

493
00:22:42,669 --> 00:22:40,039
an elliptical galaxy which is spread out

494
00:22:43,630 --> 00:22:42,679
across a filling filling volume you

495
00:22:45,190 --> 00:22:43,640
could call it sort of call it a

496
00:22:46,840 --> 00:22:45,200
football-shaped galaxy because there

497
00:22:49,560 --> 00:22:46,850
never actually circular they're always

498
00:22:54,760 --> 00:22:49,570
sort of an oblong football like shape

499
00:22:56,889 --> 00:22:54,770
then if you combine the two if you take

500
00:22:58,210 --> 00:22:56,899
that elliptical galaxy and center and

501
00:23:00,730 --> 00:22:58,220
you have that spiral the disk of the

502
00:23:04,240 --> 00:23:00,740
spiral you get a shape called a

503
00:23:06,310 --> 00:23:04,250
lenticular galaxy all right this is some

504
00:23:07,389 --> 00:23:06,320
rare o galaxy you might be able to squit

505
00:23:09,490 --> 00:23:07,399
and be able to see the outline of

506
00:23:13,360 --> 00:23:09,500
sombrero but you can see it has that

507
00:23:15,669 --> 00:23:13,370
great big bulge as well as that disc so

508
00:23:17,320 --> 00:23:15,679
these are the basic shapes of galaxies

509
00:23:18,820 --> 00:23:17,330
and I'm don't want to claim that Hubble

510
00:23:20,289 --> 00:23:18,830
discover them they were discovered

511
00:23:22,510 --> 00:23:20,299
actually by they were actually

512
00:23:25,060 --> 00:23:22,520
classified by Edwin Hubble the namesake

513
00:23:27,220 --> 00:23:25,070

of the telescope what Hubble has looked

514
00:23:29,590 --> 00:23:27,230
at are the different types of galaxies

515
00:23:32,289 --> 00:23:29,600
that go beyond this so here are two

516
00:23:35,049 --> 00:23:32,299
galaxies there to spiral galaxies that

517
00:23:36,820 --> 00:23:35,059
are appear to be interacting but they're

518
00:23:40,450 --> 00:23:36,830
not they're just passing by each other

519
00:23:43,000 --> 00:23:40,460
one is overlapping however if they did

520
00:23:45,610 --> 00:23:43,010
interact you might get galaxies that

521
00:23:47,590 --> 00:23:45,620
look like this these two galaxies are

522
00:23:49,240 --> 00:23:47,600
called the mice and you can see the

523
00:23:52,480 --> 00:23:49,250
center of the galaxies there and then

524
00:23:54,220 --> 00:23:52,490
these long tidal tails these tidal tails

525
00:23:56,409 --> 00:23:54,230
have been stretched off by the

526
00:23:59,350 --> 00:23:56,419
gravitational interaction between these

527
00:24:01,480 --> 00:23:59,360
galaxies and Hubble has studied these

528
00:24:03,880 --> 00:24:01,490
galaxies interact galaxy interactions

529
00:24:05,919 --> 00:24:03,890
and in particular on the left you see a

530
00:24:08,320 --> 00:24:05,929
ground-based image of a pair of galaxies

531
00:24:09,760 --> 00:24:08,330
called the antenna again for those long

532
00:24:11,889 --> 00:24:09,770
tidal tails looking like antennas

533
00:24:13,870 --> 00:24:11,899
sticking away from the center and in the

534
00:24:17,649 --> 00:24:13,880
Hubble image on the right you can see

535
00:24:21,220 --> 00:24:17,659
all those bright blue regions these are

536
00:24:24,700 --> 00:24:21,230
observed an ultraviolet to find out the

537
00:24:25,480 --> 00:24:24,710
details of what's going on in the galaxy

538
00:24:27,910 --> 00:24:25,490

interaction

539
00:24:31,750 --> 00:24:27,920
and we found that there were immense

540
00:24:34,210 --> 00:24:31,760
numbers of stars formed during these

541
00:24:36,730 --> 00:24:34,220
galaxies interactions they form these

542
00:24:39,040 --> 00:24:36,740
giant star clusters bigger than we

543
00:24:40,990 --> 00:24:39,050
imagined before so big that the

544
00:24:44,380 --> 00:24:41,000
astronomer called them super star

545
00:24:46,330 --> 00:24:44,390
clusters so there are a lot of these

546
00:24:48,640 --> 00:24:46,340
galaxies interactions and Hubble has

547
00:24:51,400 --> 00:24:48,650
studied a lot of them this is our

548
00:24:55,390 --> 00:24:51,410
largest press release ever when we had

549
00:24:57,160 --> 00:24:55,400
59 images of galaxies interactions and

550
00:24:59,110 --> 00:24:57,170
we can study galaxies that are coming

551
00:25:01,240 --> 00:24:59,120
together as they smash through each

552
00:25:04,990 --> 00:25:01,250
other they develop their title tails and

553
00:25:07,390 --> 00:25:05,000
come back and merge together but Hubble

554
00:25:10,270 --> 00:25:07,400
had a really special press release

555
00:25:14,110 --> 00:25:10,280
concerning our own Milky Way galaxy in

556
00:25:16,150 --> 00:25:14,120
the top left you can see an image of our

557
00:25:19,540 --> 00:25:16,160
Milky Way galaxy as it looks today and

558
00:25:22,060 --> 00:25:19,550
it is a spiral galaxy but we're inside

559
00:25:26,470 --> 00:25:22,070
the spiral so we see that edge-on view

560
00:25:28,750 --> 00:25:26,480
because we're inside that pancake and in

561
00:25:31,060 --> 00:25:28,760
the background you see a very small

562
00:25:34,780 --> 00:25:31,070
little galaxy that's the nearest large

563
00:25:37,030 --> 00:25:34,790

galaxy called Andromeda and Andromeda

564
00:25:40,870 --> 00:25:37,040
has been shown to be coming towards us

565
00:25:44,350 --> 00:25:40,880
so in the top right we have done a

566
00:25:46,020 --> 00:25:44,360
simulation of it and you can see a drama

567
00:25:48,190 --> 00:25:46,030
that is heading towards us and the

568
00:25:52,630 --> 00:25:48,200
bottom left you can see Andromeda

569
00:25:55,660 --> 00:25:52,640
getting even bigger however Hubble was

570
00:25:58,540 --> 00:25:55,670
able to measure the sideways motion of

571
00:26:00,520 --> 00:25:58,550
Andromeda to characterize the future

572
00:26:03,280 --> 00:26:00,530
collision between the Milky Way and

573
00:26:05,020 --> 00:26:03,290
Andromeda and what Hubble it was able to

574
00:26:08,680 --> 00:26:05,030
determine that no other telescope was

575
00:26:11,799 --> 00:26:08,690
able to do was that we are headed for a

576
00:26:14,680 --> 00:26:11,809
tour head-on collision the Milky Way and

577
00:26:17,830 --> 00:26:14,690
Andromeda will collide in about 4

578
00:26:20,799 --> 00:26:17,840
billion years and that collision is

579
00:26:23,200 --> 00:26:20,809
shown in the lower right then we took it

580
00:26:25,480 --> 00:26:23,210
further we followed it with a simulation

581
00:26:27,880 --> 00:26:25,490
to try and see how it would develop and

582
00:26:29,950 --> 00:26:27,890
you can see in the upper left lots of

583
00:26:32,080 --> 00:26:29,960
star formation happening during the

584
00:26:35,140 --> 00:26:32,090
collision in the upper right you can see

585
00:26:37,299 --> 00:26:35,150
the tidal tails stretching out and in

586
00:26:37,690 --> 00:26:37,309
the lower left you see the galaxies

587
00:26:40,450 --> 00:26:37,700
coming

588
00:26:42,879 --> 00:26:40,460

back together and finally the lower

589
00:26:45,490 --> 00:26:42,889
right you see that about six billion

590
00:26:48,850 --> 00:26:45,500
years from now the Milky Way and

591
00:26:53,860 --> 00:26:48,860
Andromeda will actually merge together

592
00:26:56,350 --> 00:26:53,870
to become one galaxy that is in our

593
00:26:58,240 --> 00:26:56,360
future however you don't really need to

594
00:27:00,399 --> 00:26:58,250
worry about it your kids won't see it

595
00:27:01,690 --> 00:27:00,409
your grandkids won't see it you're a

596
00:27:04,060 --> 00:27:01,700
great great great great great great

597
00:27:06,159 --> 00:27:04,070
great grandkids won't see it because

598
00:27:08,860 --> 00:27:06,169
it's all going to happen about 4 billion

599
00:27:11,500 --> 00:27:08,870
years in the future but I can say that I

600
00:27:13,299 --> 00:27:11,510
is an astronomer man I'd really love to

601
00:27:16,870 --> 00:27:13,309
see that night sky during the collision

602
00:27:19,299 --> 00:27:16,880
that'll be a sight to see alright so

603
00:27:21,519 --> 00:27:19,309
let's step up one more scale let's go up

604
00:27:24,190 --> 00:27:21,529
to the scale of the entire universe with

605
00:27:25,659 --> 00:27:24,200
its image the Hubble Ultra Deep Field or

606
00:27:28,600 --> 00:27:25,669
i'm just going to for short i'm going to

607
00:27:31,299 --> 00:27:28,610
call it the HUD f now the Hubble Ultra

608
00:27:33,340 --> 00:27:31,309
Deep Field is the longest visible light

609
00:27:37,060 --> 00:27:33,350
exposure ever taken of the universe it

610
00:27:39,240 --> 00:27:37,070
sees more galaxies and fainter galaxies

611
00:27:42,190 --> 00:27:39,250
and thus galaxies at greater distances

612
00:27:45,340 --> 00:27:42,200
than any other visible light exposure

613
00:27:47,710 --> 00:27:45,350

ever taken let me zoom in on some of the

614
00:27:49,299 --> 00:27:47,720
details so here are some of the details

615
00:27:51,789 --> 00:27:49,309
so we can see we've got some big

616
00:27:54,820 --> 00:27:51,799
galaxies we got some medium galaxies we

617
00:27:56,710 --> 00:27:54,830
got some small galaxies now I don't have

618
00:28:00,039 --> 00:27:56,720
to know exactly where these galaxies

619
00:28:01,480 --> 00:28:00,049
exist but I can tell that the bigger

620
00:28:03,879 --> 00:28:01,490
galaxies well they're probably going to

621
00:28:04,840 --> 00:28:03,889
be more nearby the medium-sized galaxies

622
00:28:07,360 --> 00:28:04,850
they're gonna be able bit further away

623
00:28:09,460 --> 00:28:07,370
and then small galaxies well they're

624
00:28:12,639 --> 00:28:09,470
going to be even more just so we're

625
00:28:15,610 --> 00:28:12,649
looking at galaxies stretched across the

626
00:28:18,549 --> 00:28:15,620
universe one of the questions you might

627
00:28:22,149 --> 00:28:18,559
have however is well just how many

628
00:28:25,240 --> 00:28:22,159
galaxies are there and this is where we

629
00:28:28,090 --> 00:28:25,250
bring up our nationwide galaxy count so

630
00:28:31,000 --> 00:28:28,100
in preparation for this teaching we said

631
00:28:33,639 --> 00:28:31,010
what can we do and involve the students

632
00:28:35,860 --> 00:28:33,649
in a science project during our national

633
00:28:38,139 --> 00:28:35,870
teachin so if you came to our teaching

634
00:28:39,909 --> 00:28:38,149
page a couple weeks ago we were able to

635
00:28:41,980 --> 00:28:39,919
participate in the nationwide galaxy cow

636
00:28:44,529 --> 00:28:41,990
and what we did is we took that Hubble

637
00:28:47,289 --> 00:28:44,539
Ultra Deep Field and we split it up into

638
00:28:50,780 --> 00:28:47,299

these small cutouts and we asked people

639
00:28:52,940 --> 00:28:50,790
to go ahead and count galaxies in

640
00:28:56,840 --> 00:28:52,950
cut outs and submit your numbers to us

641
00:29:00,080 --> 00:28:56,850
and you did we got a good number of

642
00:29:02,390 --> 00:29:00,090
responses and we get a lot of variety in

643
00:29:04,370 --> 00:29:02,400
our responses so this is the galaxy

644
00:29:07,370 --> 00:29:04,380
count distribution and you can see it

645
00:29:09,590 --> 00:29:07,380
goes from zero to 125 on the graph the

646
00:29:12,920 --> 00:29:09,600
lowest we got was around five and the

647
00:29:15,530 --> 00:29:12,930
highest we got was little over 120 so

648
00:29:17,870 --> 00:29:15,540
the same peep the same cut out being

649
00:29:20,660 --> 00:29:17,880
counted by different people comes up

650
00:29:22,820 --> 00:29:20,670
with a variety of answers now you might

651
00:29:25,760 --> 00:29:22,830
say oh well they got it right and they

652
00:29:30,200 --> 00:29:25,770
got it wrong I would say that you all

653
00:29:32,240 --> 00:29:30,210
got it right simply because we didn't

654
00:29:35,540 --> 00:29:32,250
tell you exactly what counted as a

655
00:29:36,920 --> 00:29:35,550
galaxy we let that in vague in the

656
00:29:39,650 --> 00:29:36,930
instructions and matter fact we put it

657
00:29:41,570 --> 00:29:39,660
up to you to say you should look at it

658
00:29:43,790 --> 00:29:41,580
and you should try to determine what is

659
00:29:46,430 --> 00:29:43,800
a galaxy a matter of fact we wanted you

660
00:29:49,250 --> 00:29:46,440
to work in teams because this is very

661
00:29:50,990 --> 00:29:49,260
important idea of science that science

662
00:29:52,910 --> 00:29:51,000
isn't just coming up with the right

663
00:29:55,430 --> 00:29:52,920

answer the right answer is not as

664
00:29:58,160 --> 00:29:55,440
important as the process of getting

665
00:30:00,290 --> 00:29:58,170
there and so by working in a team and

666
00:30:02,480 --> 00:30:00,300
discussing with your team well this is

667
00:30:04,640 --> 00:30:02,490
what I think a galaxy should count as or

668
00:30:07,790 --> 00:30:04,650
no no this is what I think a galaxy

669
00:30:10,490 --> 00:30:07,800
should count as that is really the best

670
00:30:13,100 --> 00:30:10,500
process of science it's that discussion

671
00:30:15,170 --> 00:30:13,110
in figuring out what you're after that's

672
00:30:18,740 --> 00:30:15,180
really where the science scientific

673
00:30:21,590 --> 00:30:18,750
insight takes place of course everyone

674
00:30:23,660 --> 00:30:21,600
does want the answer alright so let me

675
00:30:26,480 --> 00:30:23,670
give you the answer not for me as the

676
00:30:29,320 --> 00:30:26,490
astronomer but from you the folks who

677
00:30:32,990 --> 00:30:29,330
did the counting so here is your answer

678
00:30:35,300 --> 00:30:33,000
so in the HUD f galaxy counts the

679
00:30:39,920 --> 00:30:35,310
average across all of the cutouts that

680
00:30:42,200 --> 00:30:39,930
people counted was 54.4 galaxies so all

681
00:30:46,490 --> 00:30:42,210
these galaxies of all the cutouts you

682
00:30:48,200 --> 00:30:46,500
know the average number was 54 so first

683
00:30:52,460 --> 00:30:48,210
thing we want to do is estimate how many

684
00:30:54,800 --> 00:30:52,470
galaxies are in the entire HUD f but how

685
00:30:58,030 --> 00:30:54,810
are we going to do that what I need to

686
00:31:03,050 --> 00:30:58,040
tell you is that each of those cutouts

687
00:31:04,430 --> 00:31:03,060
was one percent of the HUD f we divided

688
00:31:07,310 --> 00:31:04,440

the HUD f up into

689
00:31:09,380 --> 00:31:07,320
by 10 by 10 grid and asks you to count

690
00:31:14,000 --> 00:31:09,390
the cutouts which were just one of those

691
00:31:16,100 --> 00:31:14,010
grid points so if we are going to make a

692
00:31:19,160 --> 00:31:16,110
estimate of the number of galaxies in

693
00:31:23,330 --> 00:31:19,170
the HUD f based on our average we simply

694
00:31:26,560 --> 00:31:23,340
multiply by a 100 and our estimate for

695
00:31:31,550 --> 00:31:26,570
the number of galaxies in the HUD f is

696
00:31:35,530 --> 00:31:31,560
5440 really good estimate now let's take

697
00:31:37,850 --> 00:31:35,540
it one step further if the HUD f is a

698
00:31:41,870 --> 00:31:37,860
representative sample of the entire

699
00:31:45,260 --> 00:31:41,880
night sky how much how many galaxies are

700
00:31:47,270 --> 00:31:45,270
there in the whole night sky again you

701
00:31:49,520 --> 00:31:47,280
need to know what percentage the HUD f

702
00:31:53,420 --> 00:31:49,530
is of the whole night sky to get that

703
00:31:55,370 --> 00:31:53,430
answer let me show you here is the

704
00:31:58,070 --> 00:31:55,380
apparent side here is the full moon and

705
00:32:02,060 --> 00:31:58,080
the full moon on our night sky appears

706
00:32:05,030 --> 00:32:02,070
up half a degree across the hu yep by

707
00:32:08,690 --> 00:32:05,040
comparison is only about one-tenth of

708
00:32:11,180 --> 00:32:08,700
that size ok so the heb f is small

709
00:32:14,210 --> 00:32:11,190
compared to the full moon as it appears

710
00:32:17,390 --> 00:32:14,220
from Earth the full moon although you

711
00:32:19,310 --> 00:32:17,400
might think it's awfully large well if

712
00:32:22,190 --> 00:32:19,320
you take a proper perspective view of it

713
00:32:24,320 --> 00:32:22,200

it's actually pretty small because it's

714
00:32:26,750 --> 00:32:24,330
only half a degree across and you

715
00:32:28,790 --> 00:32:26,760
remember there are 360 degrees in a

716
00:32:33,110 --> 00:32:28,800
circle so half a degree in the night sky

717
00:32:36,800 --> 00:32:33,120
isn't all that big so we're talking one

718
00:32:39,800 --> 00:32:36,810
factor in 720 in a circle and then one

719
00:32:44,270 --> 00:32:39,810
factor in 10 from that the answer is

720
00:32:46,670 --> 00:32:44,280
that there are 12 valve million seven

721
00:32:49,550 --> 00:32:46,680
hundred and forty-six thousand seven

722
00:32:53,440 --> 00:32:49,560
hundred and eighty four patches the same

723
00:32:58,280 --> 00:32:53,450
sizes HUD F across the entire night sky

724
00:33:02,990 --> 00:32:58,290
the HUD F only represents 112 million of

725
00:33:07,550 --> 00:33:03,000
the entire night sky so let's go back to

726
00:33:10,490 --> 00:33:07,560
our calculation if we have 5440 galaxies

727
00:33:13,850 --> 00:33:10,500
in the HUD f and we multiply that by

728
00:33:16,430 --> 00:33:13,860
twelve point seven million your estimate

729
00:33:17,270 --> 00:33:16,440
of the entire number of galaxies in the

730
00:33:22,090 --> 00:33:17,280
entire you

731
00:33:24,920 --> 00:33:22,100
verse is 69 billion that's kind of cool

732
00:33:27,440 --> 00:33:24,930
just doing accounting exercise in your

733
00:33:31,400 --> 00:33:27,450
classroom you can estimate the number of

734
00:33:34,220 --> 00:33:31,410
galaxies in the entire universe when

735
00:33:36,590 --> 00:33:34,230
astronomers do it we don't ask school

736
00:33:38,060 --> 00:33:36,600
kids to count our galaxies for us we

737
00:33:40,430 --> 00:33:38,070
don't even ask our graduate students to

738
00:33:42,050 --> 00:33:40,440

do that we ask our computers to do it

739
00:33:44,450 --> 00:33:42,060
and so we have very sophisticated

740
00:33:46,640 --> 00:33:44,460
computer programs to identify the

741
00:33:49,190 --> 00:33:46,650
galaxies and images like this and count

742
00:33:51,260 --> 00:33:49,200
all of them for us and so we can count

743
00:33:54,980 --> 00:33:51,270
all the galaxies in the HUD f and the

744
00:33:56,690 --> 00:33:54,990
number we get is about 10,000 now you

745
00:33:58,820 --> 00:33:56,700
should expect that you're counting will

746
00:34:01,310 --> 00:33:58,830
of course be lower simply because you

747
00:34:04,010 --> 00:34:01,320
don't can't see the very fine and faint

748
00:34:06,410 --> 00:34:04,020
pixels that a computer can see but you

749
00:34:09,830 --> 00:34:06,420
did really well and so if you take that

750
00:34:12,020 --> 00:34:09,840
10,000 number in the HUD f you can see

751
00:34:15,050 --> 00:34:12,030
that astronomers estimate that they're

752
00:34:18,980 --> 00:34:15,060
more than 100 billion galaxies in the

753
00:34:22,070 --> 00:34:18,990
entire universe now if that were all the

754
00:34:24,680 --> 00:34:22,080
HUD f was was about it still be a really

755
00:34:27,530 --> 00:34:24,690
great image but there is another story I

756
00:34:29,540 --> 00:34:27,540
want to tell you about it and here to

757
00:34:31,550 --> 00:34:29,550
illustrate that story are some of the

758
00:34:34,250 --> 00:34:31,560
most distant objects in the Hubble Ultra

759
00:34:36,800 --> 00:34:34,260
Deep Field and you can see they're not

760
00:34:40,970 --> 00:34:36,810
very exciting and galaxies there faint

761
00:34:43,730 --> 00:34:40,980
red dots small red things out of the

762
00:34:46,760 --> 00:34:43,740
furthest reaches of the universe now let

763
00:34:48,889 --> 00:34:46,770

me tell you why are they red well they

764
00:34:51,169 --> 00:34:48,899
are red because the universe is

765
00:34:54,050 --> 00:34:51,179
expanding and the light that travels

766
00:34:56,870 --> 00:34:54,060
across the expanding universe becomes

767
00:34:59,870 --> 00:34:56,880
stretched along with it recall this

768
00:35:01,970 --> 00:34:59,880
cosmological redshift because if you

769
00:35:04,850 --> 00:35:01,980
take short wavelengths and stretch them

770
00:35:07,520 --> 00:35:04,860
to longer wavelengths for visible light

771
00:35:09,650 --> 00:35:07,530
the blue is the shorter wavelengths the

772
00:35:12,170 --> 00:35:09,660
red is the longer wavelengths so the

773
00:35:15,140 --> 00:35:12,180
wavelengths stretched or the red end of

774
00:35:16,700 --> 00:35:15,150
the spectrum that's what cosmological

775
00:35:20,470 --> 00:35:16,710
redshift is and that's why these

776
00:35:24,230 --> 00:35:20,480
galaxies appear red they appear small

777
00:35:27,820 --> 00:35:24,240
because well this is a different story a

778
00:35:30,560 --> 00:35:27,830
long time ago in a galaxy far far away

779
00:35:33,350 --> 00:35:30,570
now you may recognize that

780
00:35:36,860 --> 00:35:33,360
the opening of Star Wars Episode four

781
00:35:40,820 --> 00:35:36,870
and it's actually one thing that George

782
00:35:43,700 --> 00:35:40,830
Lucas got right because when you are

783
00:35:47,020 --> 00:35:43,710
looking at a galaxy far far away you

784
00:35:49,130 --> 00:35:47,030
have to be looking at it a long time ago

785
00:35:50,780 --> 00:35:49,140
remember i talked about light traveling

786
00:35:53,690 --> 00:35:50,790
across space doesn't happen

787
00:35:56,180 --> 00:35:53,700
instantaneously light takes time to

788
00:36:00,170 --> 00:35:56,190

cross space and for these most distant

789
00:36:02,600 --> 00:36:00,180
galaxies it takes billions of years so

790
00:36:06,140 --> 00:36:02,610
we're seeing these galaxies not as they

791
00:36:09,620 --> 00:36:06,150
are today but as they were billions of

792
00:36:13,130 --> 00:36:09,630
years ago here's a diagram to illustrate

793
00:36:14,900 --> 00:36:13,140
that the bottom left you can see some

794
00:36:17,330 --> 00:36:14,910
galaxies out to about three billion

795
00:36:20,060 --> 00:36:17,340
light-years away so we're seeing them as

796
00:36:22,340 --> 00:36:20,070
they were out to 3 billion years ago and

797
00:36:24,430 --> 00:36:22,350
you can see those galaxies have the

798
00:36:27,260 --> 00:36:24,440
normal spiral shapes that we expect in

799
00:36:29,090 --> 00:36:27,270
the center circle we see galaxies from

800
00:36:33,050 --> 00:36:29,100
three to seven billion light-years away

801
00:36:35,840 --> 00:36:33,060
so three to seven billion years ago and

802
00:36:37,940 --> 00:36:35,850
they also have spiral shapes but they're

803
00:36:40,100 --> 00:36:37,950
not fully developed you know if the

804
00:36:41,300 --> 00:36:40,110
bottom ones are adult galaxies these

805
00:36:44,180 --> 00:36:41,310
middle ones maybe we'll call them

806
00:36:46,370 --> 00:36:44,190
teenager galaxies and in the top right

807
00:36:49,130 --> 00:36:46,380
you can see the galaxies that are red

808
00:36:50,600 --> 00:36:49,140
and they're small and they really don't

809
00:36:53,660 --> 00:36:50,610
have much spiral structure at all

810
00:36:56,360 --> 00:36:53,670
they're still developing these would be

811
00:37:00,470 --> 00:36:56,370
the kid galaxies as we look out into

812
00:37:03,380 --> 00:37:00,480
space we look back into time and we can

813
00:37:06,260 --> 00:37:03,390

see the development of galaxies over

814
00:37:09,080 --> 00:37:06,270
time and that is what makes the Hubble

815
00:37:11,450 --> 00:37:09,090
Ultra Deep Field so special that not

816
00:37:14,210 --> 00:37:11,460
only do we see so many galaxies stretch

817
00:37:17,180 --> 00:37:14,220
across space but also stretched across

818
00:37:20,270 --> 00:37:17,190
time and we can see the history of the

819
00:37:24,830 --> 00:37:20,280
universe by looking deep with the Hubble

820
00:37:28,600 --> 00:37:24,840
Space Telescope so we have shown you

821
00:37:31,250 --> 00:37:28,610
planets and stars and nebulae and

822
00:37:33,260 --> 00:37:31,260
galaxies and we've taken you to the edge

823
00:37:35,960 --> 00:37:33,270
of the universe Hubble as a

824
00:37:38,930 --> 00:37:35,970
general-purpose Observatory is able to

825
00:37:42,830 --> 00:37:38,940
study the complete sweep of the universe

826
00:37:44,440 --> 00:37:42,840
and its really are privileged to be able

827
00:37:46,480 --> 00:37:44,450
to bring this to you

828
00:37:49,150 --> 00:37:46,490
now I know that you have some questions

829
00:37:51,190 --> 00:37:49,160
and we asked you in advance to submit

830
00:37:53,109 --> 00:37:51,200
your questions we got a whole bunch of

831
00:37:56,440 --> 00:37:53,119
questions we chose to that we would

832
00:37:59,079 --> 00:37:56,450
answer live during the teach it so the

833
00:38:02,380 --> 00:37:59,089
first question what makes the pictures

834
00:38:04,510 --> 00:38:02,390
from Hubble so colorful because hulls

835
00:38:07,540 --> 00:38:04,520
images are just wonderfully compelling

836
00:38:10,329 --> 00:38:07,550
I'm actually going to tell you a secret

837
00:38:12,640 --> 00:38:10,339
it's not really a secret but Hubble

838
00:38:16,000 --> 00:38:12,650

takes images that are always black and

839
00:38:19,390 --> 00:38:16,010
white every image Hubble takes is black

840
00:38:22,000 --> 00:38:19,400
and white but what Hubble does is it

841
00:38:23,920 --> 00:38:22,010
takes images through filters and so the

842
00:38:25,750 --> 00:38:23,930
image on the left is goes through a red

843
00:38:27,730 --> 00:38:25,760
filter the image in the center goes

844
00:38:29,650 --> 00:38:27,740
through a green filter and the image on

845
00:38:32,290 --> 00:38:29,660
the right goes through a blue filter and

846
00:38:34,660 --> 00:38:32,300
when they come down to us at Space

847
00:38:37,540 --> 00:38:34,670
Telescope they are black and white and

848
00:38:40,240 --> 00:38:37,550
we can add color to them so that we get

849
00:38:42,099 --> 00:38:40,250
red and green and blue to represent the

850
00:38:44,740 --> 00:38:42,109
colors that they've got and then we

851
00:38:48,990 --> 00:38:44,750
combine them together we get a full

852
00:38:51,790 --> 00:38:49,000
color image up in this case a galaxy and

853
00:38:53,890 --> 00:38:51,800
in this galaxy we have used these

854
00:38:56,530 --> 00:38:53,900
broadband red green and blue filters

855
00:38:58,359 --> 00:38:56,540
just like the codes in your eye you've

856
00:39:01,599 --> 00:38:58,369
got red green and blue cones in your eye

857
00:39:03,520 --> 00:39:01,609
and so we call this sort of natural

858
00:39:06,309 --> 00:39:03,530
color because it's kind of like what

859
00:39:08,470 --> 00:39:06,319
you're I would see if you had an eyeball

860
00:39:12,490 --> 00:39:08,480
as big as the hubble space telescope's

861
00:39:14,710 --> 00:39:12,500
mirror the area are however most of

862
00:39:17,290 --> 00:39:14,720
Hubble observations are not they taken

863
00:39:19,720 --> 00:39:17,300

in these broadband filters for example

864
00:39:23,079 --> 00:39:19,730
this image of a nebula was taken in the

865
00:39:26,140 --> 00:39:23,089
light of nitrogen emission of hydrogen

866
00:39:28,450 --> 00:39:26,150
emission and oxygen emission these are

867
00:39:30,099 --> 00:39:28,460
three specific elements that that

868
00:39:32,140 --> 00:39:30,109
radiated specific wavelengths and

869
00:39:35,290 --> 00:39:32,150
Hubble's able to filter out just that

870
00:39:36,910 --> 00:39:35,300
light which is important to science now

871
00:39:40,660 --> 00:39:36,920
the night both the nitrogen and the

872
00:39:43,150 --> 00:39:40,670
hydrogen outlines are in the red part of

873
00:39:45,609 --> 00:39:43,160
the spectrum and the oxygen is in more

874
00:39:48,819 --> 00:39:45,619
in the cyan portion of the spectrum and

875
00:39:50,640 --> 00:39:48,829
we combine them together we would get an

876
00:39:53,620 --> 00:39:50,650
image like you see in the lower left

877
00:39:55,120 --> 00:39:53,630
however in that image it's very hard to

878
00:39:56,329 --> 00:39:55,130
tell what is the nitrogen and what is

879
00:39:58,219 --> 00:39:56,339
the hydrogen they're all sort of

880
00:40:00,799 --> 00:39:58,229
mixed together so it's more

881
00:40:03,589 --> 00:40:00,809
scientifically useful and I will say

882
00:40:06,459 --> 00:40:03,599
more beautiful if instead we've used

883
00:40:09,799 --> 00:40:06,469
nitrogen is red hydrogen is green and

884
00:40:12,339 --> 00:40:09,809
oxygen is blue combine those together

885
00:40:15,620 --> 00:40:12,349
and you hit the image in the lower right

886
00:40:18,259 --> 00:40:15,630
which has a little bit more more beauty

887
00:40:20,660 --> 00:40:18,269
to it but it's also much more useful in

888
00:40:23,839 --> 00:40:20,670

being able to separate out the colors

889
00:40:26,089 --> 00:40:23,849
from the different emission of the

890
00:40:28,640 --> 00:40:26,099
different atoms and that is what's

891
00:40:30,469 --> 00:40:28,650
useful scientifically we call this

892
00:40:32,479 --> 00:40:30,479
representative color because we are

893
00:40:35,299 --> 00:40:32,489
representing each filter with a

894
00:40:37,190 --> 00:40:35,309
different color it's also what we do

895
00:40:40,459 --> 00:40:37,200
when we take images in the infrared and

896
00:40:42,229 --> 00:40:40,469
the ultraviolet because what color is

897
00:40:44,509 --> 00:40:42,239
the ultraviolet what color is the

898
00:40:49,219 --> 00:40:44,519
infrared we need to take visible light

899
00:40:51,829 --> 00:40:49,229
colors to represent those the point is

900
00:40:56,120 --> 00:40:51,839
that all of the all of the images you

901
00:40:58,160 --> 00:40:56,130
see from Hubble the data is real but the

902
00:40:59,900 --> 00:40:58,170
colors of course sometimes have to

903
00:41:03,109 --> 00:40:59,910
represent other things that you can't

904
00:41:05,209 --> 00:41:03,119
see the second question we're going to

905
00:41:08,989 --> 00:41:05,219
answer today is what is the future of

906
00:41:11,479 --> 00:41:08,999
Hubble and space astronomy well the

907
00:41:14,209 --> 00:41:11,489
future of Hubble is actually very bright

908
00:41:15,829 --> 00:41:14,219
you might think oh it's 25 years it's

909
00:41:17,959 --> 00:41:15,839
getting toward the end of its life you

910
00:41:21,440 --> 00:41:17,969
know this is a retrospective no actually

911
00:41:23,989 --> 00:41:21,450
Hubble is doing really great we've been

912
00:41:26,359 --> 00:41:23,999
really happy with the way the

913
00:41:29,150 --> 00:41:26,369

observatory has functioned since the

914
00:41:30,769 --> 00:41:29,160
last service commission in 2009 the

915
00:41:32,989 --> 00:41:30,779
folks here at Space Telescope have

916
00:41:34,880 --> 00:41:32,999
learned how to operate the batteries and

917
00:41:37,009 --> 00:41:34,890
the gyroscopes and preserve do the

918
00:41:39,289 --> 00:41:37,019
observing in such ways that we are

919
00:41:42,079 --> 00:41:39,299
preserving and prolonging the life of

920
00:41:45,019 --> 00:41:42,089
the telescope the hubble is in many ways

921
00:41:47,209 --> 00:41:45,029
still at the peak of its powers and we

922
00:41:49,190 --> 00:41:47,219
expect it to last at least another five

923
00:41:51,319 --> 00:41:49,200
years and we're crossing our fingers and

924
00:41:54,049 --> 00:41:51,329
hoping that hubble will last another 10

925
00:41:56,920 --> 00:41:54,059
years yeah we might be able to get 35

926
00:42:00,979 --> 00:41:56,930
years out of this amazing telescope

927
00:42:03,620 --> 00:42:00,989
going beyond Hubble we have a new great

928
00:42:07,039 --> 00:42:03,630
Grubbs ereri from NASA called the James

929
00:42:09,200 --> 00:42:07,049
Webb Space Telescope now the James Webb

930
00:42:11,450 --> 00:42:09,210
Space Telescope is the following

931
00:42:13,880 --> 00:42:11,460
hubbell but it's a little different from

932
00:42:16,010 --> 00:42:13,890
how you can see it's got this giant

933
00:42:18,080 --> 00:42:16,020
mirror with this great big sunshade and

934
00:42:20,840 --> 00:42:18,090
that's because it is an infrared

935
00:42:24,800 --> 00:42:20,850
Observatory it will be observing an

936
00:42:27,170 --> 00:42:24,810
infrared light why the infrared well

937
00:42:29,870 --> 00:42:27,180
remember I talked about all those dust

938
00:42:32,630 --> 00:42:29,880

disks in Orion and you want to look into

939
00:42:34,310 --> 00:42:32,640
that as dark dust asst well it's hard to

940
00:42:37,820 --> 00:42:34,320
see you can't see them using visible

941
00:42:40,130 --> 00:42:37,830
light but infrared light with its longer

942
00:42:41,950 --> 00:42:40,140
wavelengths as well as the radiation

943
00:42:45,020 --> 00:42:41,960
from the dusk occurs in the infrared

944
00:42:47,840 --> 00:42:45,030
allows the james webb space telescope to

945
00:42:50,870 --> 00:42:47,850
look inside those dust disks and study

946
00:42:52,760 --> 00:42:50,880
star formation and planet formation with

947
00:42:56,960 --> 00:42:52,770
greater detail than Hubble could ever

948
00:43:00,530 --> 00:42:56,970
possibly do also when we look out at

949
00:43:02,990 --> 00:43:00,540
those distant galaxies the light that is

950
00:43:04,910 --> 00:43:03,000
stretched by cosmological redshift can

951
00:43:07,280 --> 00:43:04,920
be stretched past the visible light

952
00:43:10,940 --> 00:43:07,290
spectrum can be stretched into the

953
00:43:13,610 --> 00:43:10,950
infrared and deep into the infrared the

954
00:43:15,710 --> 00:43:13,620
HUD f runs out of galaxies after a while

955
00:43:19,340 --> 00:43:15,720
not because the galaxies aren't there

956
00:43:21,260 --> 00:43:19,350
but because Hubble can't see them the

957
00:43:23,510 --> 00:43:21,270
weight light from those galaxies has

958
00:43:25,460 --> 00:43:23,520
been stretched to the infrared and we

959
00:43:27,800 --> 00:43:25,470
need the james webb space telescope in

960
00:43:30,950 --> 00:43:27,810
order to see these most distance and the

961
00:43:32,600 --> 00:43:30,960
earliest galaxies in the universe so the

962
00:43:34,640 --> 00:43:32,610
James Webb Space Telescope is doing

963
00:43:37,790 --> 00:43:34,650

infrared observations it will have the

964
00:43:40,370 --> 00:43:37,800
resolution of Hubble in the infrared and

965
00:43:43,730 --> 00:43:40,380
be able to do science that the Hubble

966
00:43:45,710 --> 00:43:43,740
Space Telescope was not able to do now

967
00:43:49,580 --> 00:43:45,720
the James Webb Space Telescope doesn't

968
00:43:50,960 --> 00:43:49,590
launch until 2018 however that doesn't

969
00:43:53,660 --> 00:43:50,970
mean you can't get involved with the

970
00:43:56,390 --> 00:43:53,670
James Webb Space Telescope now and here

971
00:43:59,060 --> 00:43:56,400
to tell us about a project that you can

972
00:44:04,930 --> 00:43:59,070
do in your classroom is Jessica Kenny

973
00:44:08,120 --> 00:44:04,940
Space Telescope Science Institute hello

974
00:44:09,620 --> 00:44:08,130
welcome to our hangout again I we I am

975
00:44:11,240 --> 00:44:09,630
Jessica Kimmy and I will be telling you

976
00:44:14,560 --> 00:44:11,250
about the James Webb stem innovation

977
00:44:17,630 --> 00:44:14,570
project here at Space Telescope this

978
00:44:20,490 --> 00:44:17,640
project was based upon the success of

979
00:44:22,980 --> 00:44:20,500
the 2009 Hubble early release

980
00:44:25,350 --> 00:44:22,990
student pilot program is an

981
00:44:27,270 --> 00:44:25,360
interdisciplinary project where students

982
00:44:30,540 --> 00:44:27,280
are able to create and demonstrate their

983
00:44:32,970 --> 00:44:30,550
own ideas about the telescope this

984
00:44:35,940 --> 00:44:32,980
project is implemented in 50 different

985
00:44:38,550 --> 00:44:35,950
states within the US so this covers

986
00:44:40,530 --> 00:44:38,560
summer disciplines we have a music art

987
00:44:41,820 --> 00:44:40,540
in writing we have a few examples of

988
00:44:44,460 --> 00:44:41,830

some projects that students have

989
00:44:47,580 --> 00:44:44,470
completed we have students who have

990
00:44:50,790 --> 00:44:47,590
completed this project by creating songs

991
00:44:53,280 --> 00:44:50,800
through music we have students who have

992
00:44:54,960 --> 00:44:53,290
done a mural at their school that they

993
00:44:56,640 --> 00:44:54,970
devoted their summer time to create this

994
00:44:58,200 --> 00:44:56,650
mural with their parents with their

995
00:45:01,470 --> 00:44:58,210
teachers and with others in the

996
00:45:03,750 --> 00:45:01,480
community we also have social studies

997
00:45:05,880 --> 00:45:03,760
students working with this project it

998
00:45:08,490 --> 00:45:05,890
with world culture they've studied how

999
00:45:10,440 --> 00:45:08,500
James Webb will impact the world and in

1000
00:45:13,920 --> 00:45:10,450
other countries that have involved in

1001
00:45:16,140 --> 00:45:13,930
creating the telescope and we've had

1002
00:45:20,100 --> 00:45:16,150
elementary school students who created

1003
00:45:22,050 --> 00:45:20,110
this awesome J diversity mirror segments

1004
00:45:25,620 --> 00:45:22,060
they recognize these patterns very

1005
00:45:27,150 --> 00:45:25,630
similar to beehive patterns and we have

1006
00:45:28,860 --> 00:45:27,160
a few comments from teachers is the

1007
00:45:31,050 --> 00:45:28,870
first grade teacher who felt like the

1008
00:45:33,000 --> 00:45:31,060
students really were gaining

1009
00:45:35,460 --> 00:45:33,010
thought-provoking questions related to

1010
00:45:38,730 --> 00:45:35,470
the project they develop skills in

1011
00:45:41,310 --> 00:45:38,740
high-level comprehension from learning

1012
00:45:43,200 --> 00:45:41,320
about the James Webb Space Telescope we

1013
00:45:46,260 --> 00:45:43,210

have a high school teacher who would

1014
00:45:48,510 --> 00:45:46,270
allow their students to get real-world

1015
00:45:51,420 --> 00:45:48,520
connections to the soap telescopes and

1016
00:45:54,030 --> 00:45:51,430
they did 3d models they did songwriting

1017
00:45:56,850 --> 00:45:54,040
computer drawings related to James Webb

1018
00:45:58,440 --> 00:45:56,860
and here's just some inspiration from

1019
00:46:00,360 --> 00:45:58,450
students who participated in this

1020
00:46:04,100 --> 00:46:00,370
project that they're really interested

1021
00:46:07,200 --> 00:46:04,110
in there hoping that they could go and

1022
00:46:10,650 --> 00:46:07,210
take this opportunity to go in the

1023
00:46:11,790 --> 00:46:10,660
future in their careers so how do you

1024
00:46:13,410 --> 00:46:11,800
want to get involved how do you

1025
00:46:15,350 --> 00:46:13,420
participate with us to partner with us

1026
00:46:17,970 --> 00:46:15,360
we were able to give you resources

1027
00:46:20,550 --> 00:46:17,980
information from Jay diversity

1028
00:46:23,130 --> 00:46:20,560
scientists and if you complete this

1029
00:46:25,590 --> 00:46:23,140
project you will receive a high quality

1030
00:46:28,560 --> 00:46:25,600
museum quality prep for your classroom

1031
00:46:31,410 --> 00:46:28,570
and our contact information is John

1032
00:46:33,170 --> 00:46:31,420
maple we will see it's a jay maple at

1033
00:46:36,740 --> 00:46:33,180
stsci edu

1034
00:46:37,910 --> 00:46:36,750
and here is an image of the museum

1035
00:46:40,240 --> 00:46:37,920
quality poster that you will receive

1036
00:46:42,980 --> 00:46:40,250
upon completion of this project

1037
00:46:44,420 --> 00:46:42,990
fantastic and it's great that we're able

1038
00:46:47,359 --> 00:46:44,430

to get the james webb space telescope

1039
00:46:51,740 --> 00:46:47,369
into classrooms four years five years

1040
00:46:55,609 --> 00:46:51,750
before its launch so Hubble has been up

1041
00:46:58,250 --> 00:46:55,619
for 25 years and we are so excited that

1042
00:47:00,620 --> 00:46:58,260
you chose to share with us but it's not

1043
00:47:02,540 --> 00:47:00,630
over there's a lot more there's a lot

1044
00:47:04,069 --> 00:47:02,550
more to come from Hubble and we hope

1045
00:47:06,200 --> 00:47:04,079
there's a lot more interaction that you

1046
00:47:09,290 --> 00:47:06,210
can have with us here at Space Telescope

1047
00:47:11,660 --> 00:47:09,300
Science Institute we run the what we

1048
00:47:13,670 --> 00:47:11,670
call the amazing space education program

1049
00:47:15,319 --> 00:47:13,680
and if you want to see all the

1050
00:47:16,730 --> 00:47:15,329
activities and you want to keep up

1051
00:47:22,690 --> 00:47:16,740
perhaps with the future events we're

1052
00:47:27,829 --> 00:47:22,700
going to do come to our website www

1053
00:47:29,270 --> 00:47:27,839
amazing hyphen space STScI dot edu now I

1054
00:47:31,069 --> 00:47:29,280
have to tell you I think that website is

1055
00:47:33,859 --> 00:47:31,079
going to undergo an upgrade over the

1056
00:47:36,829 --> 00:47:33,869
summer but by sep tember we will be able

1057
00:47:38,870 --> 00:47:36,839
to will be a new website and we'll

1058
00:47:41,690 --> 00:47:38,880
schedule some new events to do with

1059
00:47:44,030 --> 00:47:41,700
teachers across the country if you have

1060
00:47:45,620 --> 00:47:44,040
questions or comments I know we didn't

1061
00:47:47,270 --> 00:47:45,630
answer all the questions we got too many

1062
00:47:50,359 --> 00:47:47,280
to answer I tried to answer as many of

1063
00:47:52,520 --> 00:47:50,369

my talk but you can still send us

1064
00:47:57,160 --> 00:47:52,530
questions or comments about this too

1065
00:48:00,890 --> 00:47:57,170
amazing hyphen space at stsci edu

1066
00:48:02,359 --> 00:48:00,900
finally I know that you we always go

1067
00:48:04,010 --> 00:48:02,369
through these things much too quickly

1068
00:48:05,420 --> 00:48:04,020
and you might have missed something all

1069
00:48:07,359 --> 00:48:05,430
right well the recording will be

1070
00:48:11,089 --> 00:48:07,369
available on YouTube very shortly after

1071
00:48:13,549 --> 00:48:11,099
afterwards and also we will then put it

1072
00:48:15,589 --> 00:48:13,559
up on teachertube early next week i

1073
00:48:18,260 --> 00:48:15,599
believe by tuesday of next week we'll

1074
00:48:21,230 --> 00:48:18,270
have it up on teacher tube and guess

1075
00:48:24,130 --> 00:48:21,240
what our username is there it is amazing

1076
00:48:27,589 --> 00:48:24,140
space but this time without the hyphen

1077
00:48:29,569 --> 00:48:27,599
so on behalf of Bonnie Eisen hammer the

1078
00:48:32,089 --> 00:48:29,579
office of public outreach the Space

1079
00:48:35,299 --> 00:48:32,099
Telescope Science Institute and all of

1080
00:48:36,680 --> 00:48:35,309
the folks at NASA work on Hubble thank

1081
00:48:39,470 --> 00:48:36,690
you for celebrating Hubble's 25th