STATION
LIFE

1
00:00:17,109 --> 00:00:15,589
it's all about flames fluids and

2
00:00:19,830 --> 00:00:17,119
materials research aboard the

3
00:00:22,230 --> 00:00:19,840
international space station hi i'm nasa

4
00:00:35,750 --> 00:00:22,240
astronaut tracy dyson welcome to station

5
00:00:38,790 --> 00:00:36,950
welcome back

6
00:00:40,630 --> 00:00:38,800
this month on station life we're going

7
00:00:42,869 --> 00:00:40,640
to look at how the unique environment

8
00:00:45,350 --> 00:00:42,879
onboard the international space station

9
00:00:47,670 --> 00:00:45,360
enables physical science research

10
00:00:49,029 --> 00:00:47,680
our space station is a laboratory unlike

11
00:00:51,110 --> 00:00:49,039
any on earth

12
00:00:53,270 --> 00:00:51,120
as we orbit in free fall around the

13
00:00:55,510 --> 00:00:53,280

planet we have the opportunity to

14
00:00:58,150 --> 00:00:55,520
control gravity as a variable in our

15
00:01:00,790 --> 00:00:58,160
research the pristine microgravity

16
00:01:02,389 --> 00:01:00,800
environment allows us to observe aspects

17
00:01:04,229 --> 00:01:02,399
of fundamental physics that aren't

18
00:01:07,030 --> 00:01:04,239
possible here on earth

19
00:01:08,950 --> 00:01:07,040
you see gravity often masks or distorts

20
00:01:12,230 --> 00:01:08,960
subtle effects such as surface tension

21
00:01:14,550 --> 00:01:12,240
and diffusion on iss these forces can be

22
00:01:16,390 --> 00:01:14,560
harnessed for a wide variety of physical

23
00:01:18,310 --> 00:01:16,400
science applications

24
00:01:20,230 --> 00:01:18,320
so on today's program we're going to

25
00:01:23,270 --> 00:01:20,240
look at how the lack of gravity affects

26
00:01:30,230 --> 00:01:23,280
the physical sciences of flames fluids

27
00:01:34,870 --> 00:01:32,469
the international space station is the

28
00:01:37,109 --> 00:01:34,880
largest most complex object ever

29
00:01:38,789 --> 00:01:37,119
assembled in space and is clearly

30
00:01:41,749 --> 00:01:38,799
visible from earth with nothing more

31
00:01:43,830 --> 00:01:41,759
than the naked eye

32
00:01:46,789 --> 00:01:43,840
from end to end the station is slightly

33
00:01:49,830 --> 00:01:46,799
longer than an american football field

34
00:01:51,990 --> 00:01:49,840
the the biggest shock i would say the

35
00:01:53,749 --> 00:01:52,000
biggest impact that i had

36
00:01:56,389 --> 00:01:53,759
during my flight is

37
00:01:59,350 --> 00:01:56,399
the first time i looked out the window

38
00:02:02,469 --> 00:01:59,360

of the orbiter and saw the space station

39
00:02:03,429 --> 00:02:02,479
it was huge it was huge and shiny and

40
00:02:05,429 --> 00:02:03,439
beautiful

41
00:02:06,550 --> 00:02:05,439
looking at it and knowing that a

42
00:02:08,469 --> 00:02:06,560
man-made

43
00:02:11,110 --> 00:02:08,479
structure that big

44
00:02:12,790 --> 00:02:11,120
is actually up there

45
00:02:15,270 --> 00:02:12,800
the interior of this incredible

46
00:02:18,390 --> 00:02:15,280
structure is larger than a five-bedroom

47
00:02:20,830 --> 00:02:18,400
house with two baths a gym and a

48
00:02:23,670 --> 00:02:20,840
360-degree bay

49
00:02:26,869 --> 00:02:23,680
window the station's mass is almost 1

50
00:02:30,229 --> 00:02:26,879
million pounds and it contains about 32

51
00:02:31,910 --> 00:02:30,239
000 cubic feet of living space

52
00:02:33,830 --> 00:02:31,920
the space station functions as a

53
00:02:36,150 --> 00:02:33,840
microgravity and life sciences

54
00:02:39,270 --> 00:02:36,160
laboratory a test bed for new

55
00:02:43,990 --> 00:02:39,280
technologies and as a platform for both

56
00:02:48,630 --> 00:02:46,229
the complex is made up of multiple

57
00:02:52,229 --> 00:02:48,640
interconnected modules grouped together

58
00:02:55,190 --> 00:02:52,239
at the center point of a 357 foot long

59
00:02:57,430 --> 00:02:55,200
integrated truss structure

60
00:02:59,990 --> 00:02:57,440
power is generated through four giant

61
00:03:03,589 --> 00:03:00,000
solar arrays attached to the ends of the

62
00:03:08,710 --> 00:03:05,830
the pressurized components include three

63
00:03:11,589 --> 00:03:08,720

laboratories the u.s laboratory module

64
00:03:13,990 --> 00:03:11,599
destiny the european research laboratory

65
00:03:17,509 --> 00:03:14,000
columbus and the japanese experiment

66
00:03:21,430 --> 00:03:19,350
the russian service module is the

67
00:03:23,910 --> 00:03:21,440
structural and functional center of the

68
00:03:25,750 --> 00:03:23,920
russian segment of the station

69
00:03:28,309 --> 00:03:25,760
it provides living quarters

70
00:03:32,550 --> 00:03:28,319
communication systems an exercise

71
00:03:34,229 --> 00:03:32,560
facility and flight propulsion systems

72
00:03:37,110 --> 00:03:34,239
other russian segments include the

73
00:03:41,910 --> 00:03:37,120
functional cargo block two mini research

74
00:03:46,869 --> 00:03:44,470
the italian space agency provided a

75
00:03:49,270 --> 00:03:46,879
permanent multi-purpose module which can

76
00:03:51,910 --> 00:03:49,280
host up to 16 additional racks

77
00:03:54,229 --> 00:03:51,920
containing equipment experiments and

78
00:03:56,949 --> 00:03:54,239
supplies

79
00:03:59,190 --> 00:03:56,959
there are three modules called nodes

80
00:04:01,670 --> 00:03:59,200
that connect the elements of the station

81
00:04:03,830 --> 00:04:01,680
and provide birthing ports

82
00:04:06,149 --> 00:04:03,840
the primary residential areas include

83
00:04:08,550 --> 00:04:06,159
the russian service module and node

84
00:04:11,350 --> 00:04:08,560
three tranquility which contains a

85
00:04:13,830 --> 00:04:11,360
bathroom for crew hygiene and exercise

86
00:04:17,349 --> 00:04:13,840
equipment a treadmill and a zero-g

87
00:04:21,990 --> 00:04:19,270
the quest airlock provides the

88
00:04:23,909 --> 00:04:22,000

capability for extra vehicular activity

89
00:04:25,670 --> 00:04:23,919
or evas

90
00:04:28,070 --> 00:04:25,680
this is the module that provides the

91
00:04:31,749 --> 00:04:28,080
exit for space walking astronauts to go

92
00:04:34,310 --> 00:04:31,759
outside the station to work

93
00:04:36,230 --> 00:04:34,320
the cupola is a small module designed

94
00:04:39,030 --> 00:04:36,240
for the observation of operations

95
00:04:41,110 --> 00:04:39,040
outside the space station

96
00:04:44,310 --> 00:04:41,120
similar to a bay window in a home on

97
00:04:46,310 --> 00:04:44,320
earth but with a 360 degree view

98
00:04:48,710 --> 00:04:46,320
the cupola allows crew members to

99
00:04:51,270 --> 00:04:48,720
observe the approach of vehicles as well

100
00:04:53,270 --> 00:04:51,280
as all robotic arm operations and

101
00:04:55,510 --> 00:04:53,280
spacewalks

102
00:04:57,909 --> 00:04:55,520
the canadian built space station robotic

103
00:04:59,189 --> 00:04:57,919
arm is a larger version of the arm on

104
00:05:00,950 --> 00:04:59,199
the space shuttle

105
00:05:05,189 --> 00:05:00,960
and is used to move equipment and

106
00:05:09,749 --> 00:05:07,110
the space station is the home of six

107
00:05:11,990 --> 00:05:09,759
full-time crew members and is made up of

108
00:05:13,670 --> 00:05:12,000
astronauts and cosmonauts from nations

109
00:05:16,710 --> 00:05:13,680
around the world

110
00:05:19,590 --> 00:05:16,720
more than 200 people have visited so far

111
00:05:30,550 --> 00:05:19,600
and at least another 120 will live there

112
00:05:34,310 --> 00:05:32,390
when you're up there for six months or

113
00:05:36,070 --> 00:05:34,320

in scott kelly's case an entire year

114
00:05:37,909 --> 00:05:36,080
it's really the working in space part

115
00:05:39,350 --> 00:05:37,919
that becomes kind of the thing you love

116
00:05:41,350 --> 00:05:39,360
the most it's the thing that gets you

117
00:05:42,950 --> 00:05:41,360
through the days you're working with

118
00:05:44,550 --> 00:05:42,960
these professionals on the ground and a

119
00:05:46,390 --> 00:05:44,560
lot of them have spent their entire

120
00:05:47,830 --> 00:05:46,400
lives working on these science

121
00:05:49,189 --> 00:05:47,840
experiments and here we are up there and

122
00:05:51,590 --> 00:05:49,199
we get to operate them and it's really

123
00:05:52,870 --> 00:05:51,600
an honor to get to do that and in many

124
00:05:55,670 --> 00:05:52,880
ways those are some of my fondest

125
00:05:57,270 --> 00:05:55,680
memories of being in space

126
00:05:59,270 --> 00:05:57,280
you get to you get to work these

127
00:06:00,550 --> 00:05:59,280
experiments and they're usually watching

128
00:06:02,309 --> 00:06:00,560
over your shoulder from the ground and

129
00:06:03,909 --> 00:06:02,319
there's a lot of times where i would do

130
00:06:06,550 --> 00:06:03,919
something whether it was fluids or with

131
00:06:08,150 --> 00:06:06,560
flame research it really didn't matter

132
00:06:09,749 --> 00:06:08,160
the investigator would just say whoa

133
00:06:12,070 --> 00:06:09,759
whoa wait dude do that again that was

134
00:06:14,070 --> 00:06:12,080
incredible and totally unexpected and

135
00:06:15,749 --> 00:06:14,080
that was what just made you smile big up

136
00:06:17,830 --> 00:06:15,759
there when when hey we've been flying in

137
00:06:19,670 --> 00:06:17,840
space a long long time but we are still

138
00:06:21,510 --> 00:06:19,680

doing research that has unexpected

139
00:06:22,870 --> 00:06:21,520
results every single day on the space

140
00:06:28,550 --> 00:06:22,880
station and i really love that about

141
00:06:32,550 --> 00:06:30,790
in microgravity something as simple as a

142
00:06:34,710 --> 00:06:32,560
candle flame looks and behaves

143
00:06:36,390 --> 00:06:34,720
completely different than here on earth

144
00:06:38,150 --> 00:06:36,400
scientists are studying combustion on

145
00:06:40,230 --> 00:06:38,160
the space station with the hopes to

146
00:06:44,150 --> 00:06:40,240
improve efficiency of fuels and reduce

147
00:06:48,629 --> 00:06:46,629
fire it is often said is mankind's

148
00:06:50,629 --> 00:06:48,639
oldest chemistry experiment

149
00:06:52,870 --> 00:06:50,639
for thousands of years people have been

150
00:06:55,029 --> 00:06:52,880
mixing the oxygen-rich air of the earth

151
00:06:57,270 --> 00:06:55,039
with an almost endless variety of fuels

152
00:06:58,629 --> 00:06:57,280
to produce a hot luminous flame

153
00:06:59,990 --> 00:06:58,639
there's an arc of learning about

154
00:07:02,469 --> 00:07:00,000
combustion that stretches from the

155
00:07:04,309 --> 00:07:02,479
earliest campfires of primitive humans

156
00:07:05,990 --> 00:07:04,319
to the most advanced automobiles racing

157
00:07:07,909 --> 00:07:06,000
down the super highways of the 21st

158
00:07:09,749 --> 00:07:07,919
century

159
00:07:11,990 --> 00:07:09,759
engineers studying burning to produce

160
00:07:13,749 --> 00:07:12,000
better internal combustion engines

161
00:07:16,150 --> 00:07:13,759
chemists peer into flames looking for

162
00:07:17,749 --> 00:07:16,160
exotic reactions

163
00:07:19,189 --> 00:07:17,759

chefs experiment with fire to cook

164
00:07:20,629 --> 00:07:19,199
better food

165
00:07:21,830 --> 00:07:20,639
you would think there's not much more to

166
00:07:24,230 --> 00:07:21,840
learn

167
00:07:26,309 --> 00:07:24,240
when it comes to fire flames are hard to

168
00:07:28,870 --> 00:07:26,319
understand because they're complicated

169
00:07:30,790 --> 00:07:28,880
in an ordinary candle flame thousands of

170
00:07:32,870 --> 00:07:30,800
chemical reactions take place

171
00:07:35,350 --> 00:07:32,880
hydrocarbon molecules from the wick are

172
00:07:37,830 --> 00:07:35,360
vaporized and cracked apart by heat they

173
00:07:41,350 --> 00:07:37,840
combine with oxygen to produce light

174
00:07:43,270 --> 00:07:41,360
heat carbon dioxide and water

175
00:07:45,749 --> 00:07:43,280
some of the hydrocarbon fragments form

176
00:07:47,670 --> 00:07:45,759
ring-shaped molecules called polycyclic

177
00:07:50,070 --> 00:07:47,680
aromatic hydrocarbons

178
00:07:52,230 --> 00:07:50,080
and eventually soot

179
00:07:54,629 --> 00:07:52,240
soot particles can themselves burn or

180
00:07:56,710 --> 00:07:54,639
simply drift away as smoke

181
00:07:59,270 --> 00:07:56,720
the familiar teardrop shape of the flame

182
00:08:01,749 --> 00:07:59,280
is an effect caused by gravity

183
00:08:02,869 --> 00:08:01,759
hot air rises and draws fresh cool air

184
00:08:04,790 --> 00:08:02,879
behind it

185
00:08:07,830 --> 00:08:04,800
this is called buoyancy and is what

186
00:08:09,749 --> 00:08:07,840
makes the flame shoot up and flicker

187
00:08:13,029 --> 00:08:09,759
but what happens when you light a candle

188
00:08:16,230 --> 00:08:13,039

say on the international space station

189
00:08:18,629 --> 00:08:16,240
in microgravity flames burn differently

190
00:08:21,029 --> 00:08:18,639
they form little spheres

191
00:08:22,869 --> 00:08:21,039
space station flame balls turn out to be

192
00:08:24,150 --> 00:08:22,879
wonderful mini labs for combustion

193
00:08:26,230 --> 00:08:24,160
research

194
00:08:28,629 --> 00:08:26,240
unlike flames on earth which expand

195
00:08:31,189 --> 00:08:28,639
greedily when they need more fuel flame

196
00:08:33,750 --> 00:08:31,199
balls let the oxygen come to them

197
00:08:36,070 --> 00:08:33,760
oxygen and fuel combine in a narrow zone

198
00:08:37,909 --> 00:08:36,080
at the surface of the sphere not here

199
00:08:41,190 --> 00:08:37,919
and there throughout the flame

200
00:08:43,670 --> 00:08:41,200
it's a much simpler system recently on a

201
00:08:45,509 --> 00:08:43,680
space station experiment called flex

202
00:08:47,350 --> 00:08:45,519
where scientists learn how to put out

203
00:08:49,430 --> 00:08:47,360
fires in microgravity

204
00:08:51,509 --> 00:08:49,440
they noticed small droplets of heptane

205
00:08:53,350 --> 00:08:51,519
were burning inside the flex combustion

206
00:08:56,070 --> 00:08:53,360
chamber

207
00:08:58,310 --> 00:08:56,080
as planned the flames went out but

208
00:09:00,389 --> 00:08:58,320
unexpectedly the droplets of fuel

209
00:09:02,710 --> 00:09:00,399
continued burning

210
00:09:04,630 --> 00:09:02,720
the flames are there just too faint to

211
00:09:07,509 --> 00:09:04,640
see

212
00:09:10,310 --> 00:09:07,519
these are cool flames

213
00:09:13,269 --> 00:09:10,320

ordinarily visible fires burn at a high

214
00:09:15,030 --> 00:09:13,279
temperature between 2200 and 3100

215
00:09:17,110 --> 00:09:15,040
degrees fahrenheit

216
00:09:19,750 --> 00:09:17,120
heptane flame balls on the space station

217
00:09:21,910 --> 00:09:19,760
started out in this hot fire regime but

218
00:09:24,310 --> 00:09:21,920
as the flame balls cooled and began to

219
00:09:25,509 --> 00:09:24,320
go out a different kind of burning took

220
00:09:27,670 --> 00:09:25,519
over

221
00:09:30,630 --> 00:09:27,680
cool flames burn at the relatively low

222
00:09:32,630 --> 00:09:30,640
temperature of 400 to 1000 degrees

223
00:09:34,550 --> 00:09:32,640
fahrenheit and their chemistry is

224
00:09:36,470 --> 00:09:34,560
completely different

225
00:09:39,110 --> 00:09:36,480
normal flames produce soot carbon

226
00:09:41,590 --> 00:09:39,120
dioxide and water cool flames produce

227
00:09:43,269 --> 00:09:41,600
carbon monoxide and formaldehyde

228
00:09:45,269 --> 00:09:43,279
similar cool flames have been produced

229
00:09:46,389 --> 00:09:45,279
on earth but they flicker out almost

230
00:09:48,790 --> 00:09:46,399
immediately

231
00:09:51,350 --> 00:09:48,800
on the space station however cool flames

232
00:09:52,949 --> 00:09:51,360
can burn for nearly a minute

233
00:09:55,030 --> 00:09:52,959
there are practical implications of

234
00:09:57,590 --> 00:09:55,040
these results for instance they could

235
00:09:59,430 --> 00:09:57,600
lead to cleaner auto ignitions

236
00:10:02,470 --> 00:09:59,440
one of the ideas that auto companies

237
00:10:04,790 --> 00:10:02,480
have worked on for years is hcci

238
00:10:06,069 --> 00:10:04,800

short for homogeneous charge compression

239
00:10:07,990 --> 00:10:06,079
ignition

240
00:10:10,230 --> 00:10:08,000
in the automobile cylinder instead of a

241
00:10:11,990 --> 00:10:10,240
spark there would be a gentler less

242
00:10:13,430 --> 00:10:12,000
polluting combustion process throughout

243
00:10:15,829 --> 00:10:13,440
the entire chamber

244
00:10:18,230 --> 00:10:15,839
the chemistry of hcci involves cool

245
00:10:19,829 --> 00:10:18,240
flame chemistry

246
00:10:21,269 --> 00:10:19,839
the extra control we get from the

247
00:10:23,030 --> 00:10:21,279
steady-state burning on the space

248
00:10:24,550 --> 00:10:23,040
station will give us more accurate

249
00:10:27,829 --> 00:10:24,560
chemistry values for this type of

250
00:10:38,710 --> 00:10:29,110
i'm just getting my safety cutter on the

251
00:10:41,750 --> 00:10:40,310
absolutely yeah

252
00:10:43,110 --> 00:10:41,760
it's just like in the pool instead of

253
00:10:57,030 --> 00:10:43,120
that

254
00:11:00,710 --> 00:10:59,030
as the international space station flies

255
00:11:03,750 --> 00:11:00,720
257

256
00:11:05,990 --> 00:11:03,760
statute miles over the coast of chile

257
00:11:11,030 --> 00:11:06,000
terry verts in the initial moments of

258
00:11:15,670 --> 00:11:13,350
as you can see combustion research on

259
00:11:17,910 --> 00:11:15,680
iss can have tremendous benefits back

260
00:11:19,829 --> 00:11:17,920
here on earth we also want to better

261
00:11:22,069 --> 00:11:19,839
understand the behavior of flames in

262
00:11:24,710 --> 00:11:22,079
spacecraft to guide strategies for

263
00:11:33,269 --> 00:11:24,720

extinguishing accidental fires the new

264
00:11:38,310 --> 00:11:35,750
sapphire is contained inside a two foot

265
00:11:41,350 --> 00:11:38,320
by three foot by four foot box

266
00:11:43,110 --> 00:11:41,360
that consists of an avionics bay

267
00:11:45,590 --> 00:11:43,120
containing the computer

268
00:11:48,310 --> 00:11:45,600
and instrumentation and a flow duct

269
00:11:50,150 --> 00:11:48,320
which holds the material to be burned

270
00:11:52,389 --> 00:11:50,160
this will be carried aboard orbital's

271
00:11:53,990 --> 00:11:52,399
cygnus spacecraft during a scheduled

272
00:11:56,470 --> 00:11:54,000
cargo resupply mission to the

273
00:11:57,910 --> 00:11:56,480
international space station

274
00:12:00,710 --> 00:11:57,920
once at the station

275
00:12:02,550 --> 00:12:00,720
sapphire will remain on cygnus until all

276
00:12:04,150 --> 00:12:02,560
the supplies are offloaded by the crew

277
00:12:06,310 --> 00:12:04,160
of astronauts

278
00:12:08,470 --> 00:12:06,320
once supplies are offloaded and replaced

279
00:12:10,389 --> 00:12:08,480
with trash from the iss

280
00:12:12,150 --> 00:12:10,399
cygnus will depart

281
00:12:13,190 --> 00:12:12,160
once reaching a safe distance from the

282
00:12:15,030 --> 00:12:13,200
station

283
00:12:16,629 --> 00:12:15,040
nasa glenn engineers working from

284
00:12:19,190 --> 00:12:16,639
orbital's mission control center in

285
00:12:20,550 --> 00:12:19,200
dulles virginia will remotely turn on

286
00:12:22,710 --> 00:12:20,560
the experiment

287
00:12:24,150 --> 00:12:22,720
cygnus will then be put into free drift

288
00:12:27,430 --> 00:12:24,160

while the sapphire experiment is

289
00:12:29,110 --> 00:12:27,440
conducted up to two and one half hours

290
00:12:31,030 --> 00:12:29,120
the experiments sensors and video

291
00:12:33,829 --> 00:12:31,040
cameras are designed to capture valuable

292
00:12:36,550 --> 00:12:33,839
data and imagery documenting large scale

293
00:12:37,590 --> 00:12:36,560
flame spread and material flammability

294
00:12:39,190 --> 00:12:37,600
limits

295
00:12:41,269 --> 00:12:39,200
at the conclusion of the sapphire

296
00:12:43,750 --> 00:12:41,279
experiment the cygnus vehicle will

297
00:12:45,829 --> 00:12:43,760
remain in orbit while the data captured

298
00:12:47,990 --> 00:12:45,839
is downlinked to several ground stations

299
00:12:50,150 --> 00:12:48,000
around the globe and transferred to nasa

300
00:12:51,670 --> 00:12:50,160
glenn's scientists and engineers in

301
00:12:54,069 --> 00:12:51,680
cleveland

302
00:12:55,670 --> 00:12:54,079
when downlink is complete cygnus will

303
00:12:58,069 --> 00:12:55,680
then begin its re-entry through the

304
00:13:25,350 --> 00:12:58,079
earth's atmosphere where it will burn up

305
00:13:29,269 --> 00:13:27,350
serious uh what are we gonna do today

306
00:13:31,430 --> 00:13:29,279
well today i well first i have to start

307
00:13:33,590 --> 00:13:31,440
off by saying that uh today i'm with

308
00:13:35,269 --> 00:13:33,600
someone who needs no introduction

309
00:13:37,030 --> 00:13:35,279
because you've all seen him before he's

310
00:13:40,550 --> 00:13:37,040
the guy we love

311
00:13:42,949 --> 00:13:40,560
dr don pettit welcome to station life ah

312
00:13:44,710 --> 00:13:42,959
it's it's good to be back on station i

313
00:13:46,790 --> 00:13:44,720

guess we're really not back on station

314
00:13:49,829 --> 00:13:46,800
but it's good to be here on station life

315
00:13:52,629 --> 00:13:49,839
thank you yes and um i am just beyond

316
00:13:54,629 --> 00:13:52,639
excited today because don is not only

317
00:13:56,790 --> 00:13:54,639
one of the most fantastic astronauts

318
00:13:59,670 --> 00:13:56,800
ever he's like one of my favorite people

319
00:14:02,310 --> 00:13:59,680
so this is a landmark event in station

320
00:14:05,509 --> 00:14:02,320
life history that we have with us and we

321
00:14:07,269 --> 00:14:05,519
both studied chemistry in college and

322
00:14:11,110 --> 00:14:07,279
look at what he's wearing see i've got

323
00:14:13,750 --> 00:14:11,120
my periodic table shirt on okay okay

324
00:14:16,870 --> 00:14:13,760
coffee cup coffee cups so

325
00:14:18,949 --> 00:14:16,880
we have the first generation the second

326
00:14:21,910 --> 00:14:18,959
generation and both of these have been

327
00:14:24,389 --> 00:14:21,920
on station this is uh a food grade

328
00:14:29,269 --> 00:14:24,399
plastic so it meets flight safety and

329
00:14:34,710 --> 00:14:32,230
a variant of the second generation

330
00:14:37,030 --> 00:14:34,720
what's that for well this this is for

331
00:14:38,310 --> 00:14:37,040
earth because this is slip cast out of

332
00:14:39,990 --> 00:14:38,320
porcelain

333
00:14:43,350 --> 00:14:40,000
and it has this really

334
00:14:46,870 --> 00:14:43,360
cool smooth look that shows off the form

335
00:14:49,910 --> 00:14:46,880
and the beauty of the design of this

336
00:14:52,629 --> 00:14:49,920
yeah but but porcelain is breakable you

337
00:14:53,910 --> 00:14:52,639
can make these sharp shards and in a

338
00:14:55,509 --> 00:14:53,920

weightless environment they could float

339
00:14:57,509 --> 00:14:55,519
around they could get in your eye or

340
00:14:59,430 --> 00:14:57,519
even worse you could inhale one of these

341
00:15:01,670 --> 00:14:59,440
shades get them in your lungs so so we

342
00:15:03,590 --> 00:15:01,680
can't take the porcelain ones on orbit

343
00:15:05,670 --> 00:15:03,600
but they're really cool looking and we

344
00:15:08,949 --> 00:15:05,680
can use them here on earth awesome shall

345
00:15:12,710 --> 00:15:11,110
notice your nose goes right in the cup

346
00:15:13,990 --> 00:15:12,720
and you get this

347
00:15:20,389 --> 00:15:14,000
burst of

348
00:15:24,069 --> 00:15:22,629
that's a good mix of cream you like that

349
00:15:25,829 --> 00:15:24,079
yeah yeah

350
00:15:28,550 --> 00:15:25,839
and oh let me read what it says it says

351
00:15:30,710 --> 00:15:28,560
space cup and that's the official name

352
00:15:32,949 --> 00:15:30,720
of this that's the op nom

353
00:15:34,710 --> 00:15:32,959
for the space station the official

354
00:15:36,470 --> 00:15:34,720
sanctioned space station experiment it's

355
00:15:38,949 --> 00:15:36,480
a the name of the experiment is

356
00:15:42,310 --> 00:15:38,959
capillary beverage capillary beverage

357
00:15:44,790 --> 00:15:42,320
and the name of the cup is space cup

358
00:15:46,870 --> 00:15:44,800
and and then there are words on it says

359
00:15:48,230 --> 00:15:46,880
capillary experiments international

360
00:15:50,310 --> 00:15:48,240
space station

361
00:15:53,590 --> 00:15:50,320
skeletonized nasa meatball this would be

362
00:15:55,829 --> 00:15:53,600
a collector's item for sure

363
00:15:58,069 --> 00:15:55,839

i was seeking tracy i want to go back up

364
00:16:00,710 --> 00:15:59,110
if you

365
00:16:03,350 --> 00:16:00,720
look at everything that i will have

366
00:16:05,990 --> 00:16:03,360
accomplished in my life

367
00:16:06,870 --> 00:16:06,000
in 400 years nobody even remember that i

368
00:16:08,790 --> 00:16:06,880
was

369
00:16:11,670 --> 00:16:08,800
even walked the surface of earth or

370
00:16:14,230 --> 00:16:11,680
floated around in space however

371
00:16:16,710 --> 00:16:14,240
i predicted in 400 years

372
00:16:19,189 --> 00:16:16,720
people living and working in space will

373
00:16:22,470 --> 00:16:19,199
be drinking sipping and toasting out of

374
00:16:23,910 --> 00:16:22,480
cups based on my design yes and and you

375
00:16:26,069 --> 00:16:23,920
will there will be

376
00:16:27,829 --> 00:16:26,079
you'll be legend you are like what am i

377
00:16:28,710 --> 00:16:27,839
talking about they won't remember

378
00:16:31,829 --> 00:16:28,720
anything

379
00:16:32,790 --> 00:16:31,839
like do you remember who invented fire

380
00:16:35,990 --> 00:16:32,800
uh

381
00:16:38,150 --> 00:16:36,000
let's see and and who invented the wheel

382
00:16:40,150 --> 00:16:38,160
no you see nobody needs to remember who

383
00:16:42,069 --> 00:16:40,160
did these states the important thing is

384
00:16:44,790 --> 00:16:42,079
you got to know how to build a wheel you

385
00:16:46,870 --> 00:16:44,800
got to know how to control fire and then

386
00:16:49,269 --> 00:16:46,880
your civilization could take off and in

387
00:16:50,790 --> 00:16:49,279
space you don't need to remember who

388
00:16:52,470 --> 00:16:50,800

messed with the

389
00:16:54,550 --> 00:16:52,480
surface chemistry to make these but you

390
00:16:56,629 --> 00:16:54,560
need to know that you know how to make

391
00:16:58,710 --> 00:16:56,639
them and that you can use them and it

392
00:17:01,189 --> 00:16:58,720
will help

393
00:17:03,590 --> 00:17:01,199
build the civil

394
00:17:05,189 --> 00:17:03,600
civilized nature of human beings

395
00:17:08,630 --> 00:17:05,199
interacting with each other when you're

396
00:17:10,789 --> 00:17:08,640
in a weightless environment well don

397
00:17:13,350 --> 00:17:10,799
i've just had so much fun having you on

398
00:17:16,150 --> 00:17:13,360
station life and sharing your invention

399
00:17:17,909 --> 00:17:16,160
and your passion for science and and

400
00:17:19,510 --> 00:17:17,919
coffee and bringing people together and

401
00:17:23,110 --> 00:17:19,520
i think you've done that in a number of

402
00:17:25,110 --> 00:17:23,120
ways but none so um illustrative as the

403
00:17:35,110 --> 00:17:25,120
space

404
00:17:40,150 --> 00:17:38,150
a normal coffee cup or a normal open

405
00:17:41,590 --> 00:17:40,160
container just simply won't work in a

406
00:17:43,430 --> 00:17:41,600
weightless environment because the

407
00:17:45,510 --> 00:17:43,440
liquid will

408
00:17:47,590 --> 00:17:45,520
be in the bottom of the cup and you tip

409
00:17:49,590 --> 00:17:47,600
it up and it still stays in the bottom

410
00:17:51,750 --> 00:17:49,600
of the cup if you move it around too

411
00:17:54,710 --> 00:17:51,760
violently it'll all splash out and make

412
00:17:57,270 --> 00:17:54,720
a big mess so we end up having to drink

413
00:17:59,190 --> 00:17:57,280

our beverages through a straw from a bag

414
00:18:01,990 --> 00:17:59,200
makes you feel like you're a big insect

415
00:18:03,990 --> 00:18:02,000
sucking the juices from another insect i

416
00:18:05,270 --> 00:18:04,000
wanted to see if i could figure out a

417
00:18:07,750 --> 00:18:05,280
way

418
00:18:09,590 --> 00:18:07,760
to have an open container cup in a

419
00:18:13,190 --> 00:18:09,600
weightless environment which would allow

420
00:18:14,870 --> 00:18:13,200
you to drink your tea and your coffee in

421
00:18:17,750 --> 00:18:14,880
a manner that's commensurate with how

422
00:18:20,789 --> 00:18:17,760
people drink their beverages on earth

423
00:18:22,710 --> 00:18:20,799
taking some of my surface chemistry that

424
00:18:26,150 --> 00:18:22,720
i learned in college

425
00:18:27,510 --> 00:18:26,160
i devised a cup with a special shape the

426
00:18:30,310 --> 00:18:27,520
cross section looks kind of like an

427
00:18:32,390 --> 00:18:30,320
airplane wing where it has a cusp and

428
00:18:35,029 --> 00:18:32,400
the cusp will

429
00:18:36,630 --> 00:18:35,039
allow channel flow so the liquid from

430
00:18:39,270 --> 00:18:36,640
the bottom of the cup will float up and

431
00:18:41,029 --> 00:18:39,280
just park itself right next to the rim

432
00:18:44,150 --> 00:18:41,039
and then you can drink it

433
00:18:46,150 --> 00:18:44,160
and it allows a crew to share a communal

434
00:18:47,669 --> 00:18:46,160
beverage you could share tea

435
00:18:49,350 --> 00:18:47,679
maybe you just come in from doing a

436
00:18:51,190 --> 00:18:49,360
space walk or something you want to

437
00:18:54,150 --> 00:18:51,200
celebrate a little bit if you have a

438
00:18:55,830 --> 00:18:54,160

real cup an open container it's so

439
00:18:58,230 --> 00:18:55,840
ingrained in human beings it's so

440
00:19:00,390 --> 00:18:58,240
ingrained in culture it adds back the

441
00:19:17,669 --> 00:19:00,400
dimension of what it's like to be a

442
00:19:17,679 --> 00:19:40,870
foreign

443
00:19:44,150 --> 00:19:41,909
okay

444
00:19:45,350 --> 00:19:44,160
flames and fluids are acting a little

445
00:19:46,789 --> 00:19:45,360
differently

446
00:19:48,870 --> 00:19:46,799
but that's not all

447
00:19:51,510 --> 00:19:48,880
take a look at how microgravity affects

448
00:19:54,789 --> 00:19:51,520
colloids magnetic fluids and smart

449
00:19:59,750 --> 00:19:57,190
if you have a smartphone take it out and

450
00:20:02,230 --> 00:19:59,760
run your fingers along the glass surface

451
00:20:03,350 --> 00:20:02,240
it's cool to the touch incredibly thin

452
00:20:06,070 --> 00:20:03,360
and strong

453
00:20:07,750 --> 00:20:06,080
and almost impervious to scratching

454
00:20:10,149 --> 00:20:07,760
you're now in contact with a smart

455
00:20:14,549 --> 00:20:10,159
material

456
00:20:16,470 --> 00:20:14,559
instead they're designed by engineers

457
00:20:18,549 --> 00:20:16,480
working at the molecular level to

458
00:20:21,669 --> 00:20:18,559
produce substances made to order for

459
00:20:23,830 --> 00:20:21,679
futuristic applications

460
00:20:25,830 --> 00:20:23,840
the corning gorilla glass that overlays

461
00:20:27,350 --> 00:20:25,840
the displays of many smartphones is a

462
00:20:29,830 --> 00:20:27,360
great example

463
00:20:31,909 --> 00:20:29,840

it gets its toughness in part from fat

464
00:20:33,750 --> 00:20:31,919
potassium ions stuffed into the empty

465
00:20:35,909 --> 00:20:33,760
spaces between old-fashioned glass

466
00:20:37,510 --> 00:20:35,919
molecules

467
00:20:39,909 --> 00:20:37,520
when the molten glass cools during

468
00:20:42,310 --> 00:20:39,919
manufacturing dense pack molecules

469
00:20:44,230 --> 00:20:42,320
solidify into a transparent armor that

470
00:20:46,310 --> 00:20:44,240
gives gorilla glass as extraordinary

471
00:20:48,549 --> 00:20:46,320
properties

472
00:20:51,110 --> 00:20:48,559
around the world designers are working

473
00:20:53,350 --> 00:20:51,120
on other smart materials such as alloys

474
00:20:55,029 --> 00:20:53,360
that can change shape on demand

475
00:20:57,669 --> 00:20:55,039
plastics that heal themselves when

476
00:20:59,909 --> 00:20:57,679
ruptured and fluids that obey magnetic

477
00:21:02,549 --> 00:20:59,919
commands to flow or stiffen under

478
00:21:04,870 --> 00:21:02,559
computer control one of the greatest

479
00:21:06,789 --> 00:21:04,880
challenges in creating a smart material

480
00:21:08,710 --> 00:21:06,799
is arranging the molecules

481
00:21:10,230 --> 00:21:08,720
they're so small

482
00:21:12,470 --> 00:21:10,240
we want to create a new class of

483
00:21:15,110 --> 00:21:12,480
materials beyond smart

484
00:21:17,990 --> 00:21:15,120
we need genius materials materials that

485
00:21:21,990 --> 00:21:19,909
the research to accomplish this is

486
00:21:23,350 --> 00:21:22,000
already underway on the international

487
00:21:25,830 --> 00:21:23,360
space station

488
00:21:29,029 --> 00:21:25,840

dr first is the principal investigator

489
00:21:31,430 --> 00:21:29,039
of an experiment called in space 3.

490
00:21:33,510 --> 00:21:31,440
in the microgravity of earth orbit

491
00:21:35,750 --> 00:21:33,520
vials of fluid mixed with very small

492
00:21:37,909 --> 00:21:35,760
colloidal particles about a millionth of

493
00:21:39,510 --> 00:21:37,919
a meter in diameter are exposed to

494
00:21:41,510 --> 00:21:39,520
magnetic fields

495
00:21:43,270 --> 00:21:41,520
magnetism can be switched on and off

496
00:21:45,430 --> 00:21:43,280
again very rapidly

497
00:21:47,590 --> 00:21:45,440
this jostles the particles causing them

498
00:21:49,510 --> 00:21:47,600
to bump together and self-assemble into

499
00:21:51,110 --> 00:21:49,520
microscopic structures

500
00:21:53,190 --> 00:21:51,120
these structures can be very difficult

501
00:21:55,510 --> 00:21:53,200
to predict even using cutting-edge

502
00:21:57,430 --> 00:21:55,520
models running on supercomputers

503
00:21:59,669 --> 00:21:57,440
astronauts enjoy watching this process

504
00:22:01,909 --> 00:21:59,679
in action through microscopes because

505
00:22:03,590 --> 00:22:01,919
the samples are backlit by a green lamp

506
00:22:06,310 --> 00:22:03,600
they sometimes call it the green blob

507
00:22:10,549 --> 00:22:08,149
first recently won an award from the

508
00:22:12,789 --> 00:22:10,559
american astronautical society for his

509
00:22:15,190 --> 00:22:12,799
work on in space 3.

510
00:22:16,789 --> 00:22:15,200
just by toggling a magnetic field we're

511
00:22:19,029 --> 00:22:16,799
learning how to take many kinds of

512
00:22:20,950 --> 00:22:19,039
microscopic building blocks and get them

513
00:22:23,750 --> 00:22:20,960

to spontaneously form interesting

514
00:22:27,750 --> 00:22:25,590
recently observers have seen the

515
00:22:29,270 --> 00:22:27,760
colloidal particles forming long fibrous

516
00:22:30,870 --> 00:22:29,280
chains

517
00:22:32,470 --> 00:22:30,880
first speculates that these could lead

518
00:22:35,830 --> 00:22:32,480
to materials that conduct heat or

519
00:22:37,270 --> 00:22:35,840
electricity in only one direction

520
00:22:39,190 --> 00:22:37,280
the experiment has also yielded

521
00:22:41,750 --> 00:22:39,200
crystalline structures that the team is

522
00:22:43,830 --> 00:22:41,760
just beginning to investigate

523
00:22:45,909 --> 00:22:43,840
the fluids underlying these tests are

524
00:22:48,549 --> 00:22:45,919
themselves very smart

525
00:22:50,870 --> 00:22:48,559
they're called magneto-rheological or mr

526
00:22:54,070 --> 00:22:50,880
fluids because they harden or change

527
00:22:56,310 --> 00:22:54,080
shape when they feel a magnetic field

528
00:22:57,990 --> 00:22:56,320
if you own a sports or luxury car you

529
00:23:00,230 --> 00:22:58,000
might have mr fluids in your shock

530
00:23:02,549 --> 00:23:00,240
absorbers the stiffness of magnetic

531
00:23:04,710 --> 00:23:02,559
shocks can be electronically adjusted

532
00:23:06,789 --> 00:23:04,720
thousands of times per second providing

533
00:23:08,710 --> 00:23:06,799
a remarkably smooth ride

534
00:23:10,310 --> 00:23:08,720
similar but more powerful devices have

535
00:23:13,110 --> 00:23:10,320
been installed at japan's national

536
00:23:15,430 --> 00:23:13,120
museum of emerging science and china's

537
00:23:17,270 --> 00:23:15,440
daunting lake bridge

538
00:23:20,789 --> 00:23:17,280

they're there to counteract vibrations

539
00:23:22,870 --> 00:23:20,799
caused by earthquakes and gusts of wind

540
00:23:24,710 --> 00:23:22,880
some researchers have speculated that mr

541
00:23:26,710 --> 00:23:24,720
fluids might one day flow through the

542
00:23:27,830 --> 00:23:26,720
actuators and hydraulic dampers of

543
00:23:29,830 --> 00:23:27,840
robots

544
00:23:31,590 --> 00:23:29,840
moving artificial joints and limbs in

545
00:23:33,190 --> 00:23:31,600
lifelike fashion

546
00:23:35,190 --> 00:23:33,200
scientists and researchers are using

547
00:23:37,029 --> 00:23:35,200
these fluids as a laboratory for

548
00:23:39,750 --> 00:23:37,039
studying self-assembly

549
00:23:41,750 --> 00:23:39,760
mr fluids are by definition responsive

550
00:23:44,630 --> 00:23:41,760
to the magnetic nudging that sets

551
00:23:46,870 --> 00:23:44,640
self-assembly in motion furthermore in

552
00:23:49,669 --> 00:23:46,880
space the particles don't sediment out

553
00:23:52,149 --> 00:23:49,679
due to gravity we can study the full 3d

554
00:23:53,909 --> 00:23:52,159
evolution of the material

555
00:23:56,070 --> 00:23:53,919
varying the shape of the colloidal

556
00:23:58,390 --> 00:23:56,080
particles the cadence of magnetic

557
00:24:00,310 --> 00:23:58,400
toggling the temperature of the fluid

558
00:24:02,149 --> 00:24:00,320
and other factors will allow researchers

559
00:24:04,710 --> 00:24:02,159
and astronauts to further explore the

560
00:24:06,230 --> 00:24:04,720
frontiers of self-assembly

561
00:24:07,110 --> 00:24:06,240
touch the surface of your smartphone

562
00:24:09,269 --> 00:24:07,120
again

563
00:24:11,590 --> 00:24:09,279

that's just the beginning

564
00:24:13,830 --> 00:24:11,600
as you can see our international space

565
00:24:16,310 --> 00:24:13,840
station is an unprecedented research

566
00:24:18,230 --> 00:24:16,320
platform in space allowing researchers

567
00:24:20,710 --> 00:24:18,240
and scientists to conduct experiments

568
00:24:22,549 --> 00:24:20,720
that can't be done anywhere else

569
00:24:24,470 --> 00:24:22,559
this work off the earth will lead to a

570
00:24:26,870 --> 00:24:24,480
better understanding of the fundamentals

571
00:24:29,350 --> 00:24:26,880
of combustion surface tension and

572
00:24:31,350 --> 00:24:29,360
colloids in the absence of gravity

573
00:24:33,590 --> 00:24:31,360
benefiting us by helping us to make more

574
00:24:36,390 --> 00:24:33,600
efficient combustion engines better

575
00:24:38,870 --> 00:24:36,400
portable medical diagnostics stronger

576
00:24:40,870 --> 00:24:38,880
lighter alloys medicines with a longer

577
00:24:42,870 --> 00:24:40,880
shelf life and buildings that are more

578
00:24:44,310 --> 00:24:42,880
resistant to earthquakes

579
00:24:46,470 --> 00:24:44,320
research on the international space

580
00:24:47,750 --> 00:24:46,480
station continues to improve life here

581
00:24:49,750 --> 00:24:47,760
on the earth

582
00:24:51,430 --> 00:24:49,760
be sure to stay in touch and follow us

583
00:24:53,190 --> 00:24:51,440
on facebook and twitter for the latest

584
00:24:55,430 --> 00:24:53,200
research news and don't forget to

585
00:24:57,430 --> 00:24:55,440
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