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00:00:00,000 --> 00:00:29,800

The Earth, home to millions of species.

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00:00:29,800 --> 00:00:36,800

But what might live beyond?

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00:00:36,800 --> 00:00:51,800

Astronomers have discovered thousands of planets outside our solar system.

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00:00:51,800 --> 00:00:58,800

They believe there are trillions more.

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00:00:58,800 --> 00:01:18,800

If life exists on only a fraction of them, then the universe must be alive.

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00:01:18,800 --> 00:01:43,800

All living things have the same needs to feed, reproduce and evolve.

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00:01:43,800 --> 00:02:02,800

By applying the laws of life on Earth to the rest of the universe, it's possible to imagine what could live on alien worlds.

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00:02:13,800 --> 00:02:35,800

Most planets we know of are so hellish, it seems impossible that anything could live.

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00:02:36,800 --> 00:02:44,800

But it's amazing where life can take hold.

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00:02:44,800 --> 00:02:50,800

For as long as I can remember, my mom always told me I was an alien.

11

00:02:50,800 --> 00:02:57,800

Because I just had my mind on outer space from the beginning.

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00:02:57,800 --> 00:03:22,800

I just had always known that I wanted to get out there and explore the universe.

13

00:03:22,800 --> 00:03:26,800

This is the most incredible place I've ever seen.

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00:03:26,800 --> 00:03:33,800

This is what I dream other planets looking like. It's incredible.

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00:03:33,800 --> 00:03:39,800

So, yeah.

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00:03:39,800 --> 00:03:48,800

The Danakal Depression is known locally as the Gateway to Hell.

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00:03:48,800 --> 00:03:54,800

120 meters below sea level and volcanic.

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00:03:54,800 --> 00:04:00,800

It's the hottest place on Earth.

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00:04:00,800 --> 00:04:12,800

Now, what's 79C? 82C? This one's topping out at 87.

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00:04:12,800 --> 00:04:23,800

If life can exist here, it could exist on any number of worlds in the universe.

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00:04:23,800 --> 00:04:29,800

Life on other planets, they're going to have chemistry, whether it looks exactly like ours, we don't know.

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00:04:29,800 --> 00:04:35,800

But they're going to have chemistry that helps them live and that chemistry is going to be subject to limits.

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00:04:35,800 --> 00:04:39,800

For example, our life is made up of cells.

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00:04:39,800 --> 00:04:44,800

Inside these cells, we have biomolecules that allow the cells to function and live and work.

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00:04:44,800 --> 00:04:49,800

That's our machinery that runs and makes this chemistry happen that keeps life living.

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00:04:49,800 --> 00:05:01,800

And so we really want to understand how that machinery works and what's going to make that machinery break down.

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00:05:01,800 --> 00:05:09,800

Until recently, it was assumed Danakal was too extreme to support life.

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00:05:09,800 --> 00:05:17,800

But astrobiologists come here to look for simple single-celled microbes.

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00:05:17,800 --> 00:05:33,800

Known as extremophiles.

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00:05:33,800 --> 00:05:46,800

Microbes are too small to see with the naked eye, so it's not going to be as simple as taking a little bit of water out of a lake and putting it under a microscope and seeing lots of teeming bugs.

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00:05:47,800 --> 00:06:05,800

The only way to detect the presence of extremophiles is to find traces of their DNA using a portable genetic sequencer.

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00:06:05,800 --> 00:06:12,800

This is a very small device and it's very substantive to temperature. And we're in one of the hottest places on the planet Earth.

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00:06:12,800 --> 00:06:16,800

So here in the field right now, we do a cool block to kind of keep it cool.

34

00:06:16,800 --> 00:06:20,800

And we have our channels running.

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00:06:20,800 --> 00:06:35,800

And we have sequencing. We actually have sequencing happening. We have DNA in here. Excellent.

36

00:06:36,800 --> 00:06:48,800

Sequencing of DNA is proof that extremophiles can survive in the acidic waters of Danakal.

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00:06:48,800 --> 00:07:03,800

These guys are like the superheroes of microbes and it's just amazing as we learn more and more about the different strategies and mechanisms that they come up with to survive these kinds of environments.

38

00:07:03,800 --> 00:07:22,800

Finding things alive here opens up an intriguing possibility that some life forms are tough enough to survive anywhere, even in the deepest reaches of space.

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00:07:23,800 --> 00:07:33,800

A red dwarf star.

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00:07:38,800 --> 00:07:42,800

The most common type of star in our galaxy.

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00:07:52,800 --> 00:08:03,800

Imagine a planet in such a close orbit, its rotation is locked by the star's gravity.

42

00:08:03,800 --> 00:08:09,800

So it always shows the same face to its sun.

43

00:08:10,800 --> 00:08:20,800

This is Janus.

44

00:08:28,800 --> 00:08:33,800

How would life adapt on such an extreme world?

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00:08:39,800 --> 00:08:46,800

On one side of the planet, it's always daytime. A searing desert.

46

00:08:50,800 --> 00:08:56,800

On the other side, it's forever night. A frozen shadow land.

47

00:08:56,800 --> 00:09:08,800

Squeezed between the two, a sliver of perpetual twilight.

48

00:09:09,800 --> 00:09:18,800

Freezing meltwater flows from the cold side, carving canyons through the landscape.

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00:09:18,800 --> 00:09:28,800

Even here, where the planet's most hospitable, there's little vegetation.

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00:09:39,800 --> 00:09:51,800

But deep in these canyons lives an extraordinary five-legged creature. A pentapod.

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00:09:51,800 --> 00:10:05,800

No bigger than a cat, it's the dominant life form on Janus, capable of adapting to any conditions.

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00:10:09,800 --> 00:10:15,800

On the cold side, it's stocky and hairy.

53

00:10:19,800 --> 00:10:26,800

On the hot side, it's shiny, slender and skittish.

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00:10:26,800 --> 00:10:33,800

Pentapods can become whatever they need to be, in order to survive.

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00:10:39,800 --> 00:10:47,800

On Earth, all animals adapt to fit their environment.

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00:10:50,800 --> 00:10:56,800

But some are more adaptable than others.

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00:10:56,800 --> 00:11:03,800

This trail that I just came across here, it's a beautifully manicured trail.

58

00:11:03,800 --> 00:11:07,800

And you would think it was made by some bigger animal, or maybe even the human.

59

00:11:07,800 --> 00:11:10,800

But it's actually made by ants.

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00:11:10,800 --> 00:11:14,800

It's a leaf cutter ant in particular.

61

00:11:14,800 --> 00:11:17,800

It's a leaf cutter ant.

62

00:11:17,800 --> 00:11:21,800

It's a leaf cutter ant in particular.

63

00:11:21,800 --> 00:11:27,800

It all looks quiet right now, but if we come back at night, this will actually turn into an ant's superhighway,

64

00:11:27,800 --> 00:11:33,800

with leaves just streaming up towards their nest.

65

00:11:48,800 --> 00:11:53,800

Oh wow, look at that!

66

00:11:53,800 --> 00:11:57,800

This is the ant nest.

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00:11:57,800 --> 00:12:03,800

You can really see into the heart of this colony, there's a lot going on.

68

00:12:06,800 --> 00:12:11,800

There's actually, for leaf cutter ants, there's different casts.

69

00:12:12,800 --> 00:12:16,800

There's the soldiers, there are different workers.

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00:12:16,800 --> 00:12:18,800

There's also the queen.

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00:12:18,800 --> 00:12:21,800

She's the only one who's laying eggs, and there's only a single queen.

72

00:12:21,800 --> 00:12:24,800

Without her, none of this would be here.

73

00:12:26,800 --> 00:12:31,800

An ant colony depends on the division of labour.

74

00:12:32,800 --> 00:12:39,800

Different casts have different jobs, and they come in all shapes and sizes.

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00:12:42,800 --> 00:12:47,800

I just grabbed one of the soldiers, and I also grabbed the really, really small worker.

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00:12:47,800 --> 00:12:52,800

It's not the smallest worker in this colony, but it's pretty close.

77

00:12:52,800 --> 00:12:56,800

The soldiers I barely can hold her, it's really hard.

78

00:12:56,800 --> 00:13:01,800

I can feel her power, I can feel, she's trying to get out, her jaws are wide open.

79

00:13:01,800 --> 00:13:08,800

But the difference is incredible, and to think that they all started from the same larva.

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00:13:11,800 --> 00:13:15,800

All ants in a colony are closely related.

81

00:13:16,800 --> 00:13:19,800

They share most of the same genes.

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00:13:20,800 --> 00:13:29,800

But as they grow up, some genes are switched on, others switched off, depending on the food they are fed.

83

00:13:31,800 --> 00:13:37,800

Any of them can become workers, foragers, or soldiers.

84

00:13:41,800 --> 00:13:46,800

So this ability to create such different shapes and forms from the same blueprint.

85

00:13:46,800 --> 00:13:52,800

This is actually called polyphenism, and poly just means many, and phenism would be shapes.

86

00:14:00,800 --> 00:14:05,800

Oh, the spider just did exactly what I was trying to avoid all night.

87

00:14:05,800 --> 00:14:09,800

She walked exactly into one of these trails, of these leaf cutters here.

88

00:14:09,800 --> 00:14:12,800

And that's not good news.

89

00:14:13,800 --> 00:14:17,800

So here you really see the power of these soldiers and their jaws.

90

00:14:18,800 --> 00:14:21,800

It's something that disturbs the colony.

91

00:14:21,800 --> 00:14:25,800

It's their job to come in and get it, and it's exactly what they did.

92

00:14:33,800 --> 00:14:35,800

But, wow.

93

00:14:40,800 --> 00:14:42,800

Ah!

94

00:14:42,800 --> 00:14:44,800

Alright, I'm already being attacked.

95

00:14:44,800 --> 00:14:46,800

Oh, that's gonna hurt.

96

00:14:46,800 --> 00:14:48,800

Yeah, now, come and find me.

97

00:14:53,800 --> 00:15:00,800

So any creature that has this ability to morph and react to changes in its environment as quickly as ants can do,

98

00:15:00,800 --> 00:15:05,800

has an amazing advantage to not just survive, but actually dominate its world.

99

00:15:10,800 --> 00:15:12,800

So, what do you think?

100

00:15:21,800 --> 00:15:26,800

On Janus, pentapods are masters of polyphenism.

101

00:15:29,800 --> 00:15:33,800

Like ants, they're able to develop into different forms.

102

00:15:34,800 --> 00:15:38,800

But they all begin life in the same place.

103

00:15:41,800 --> 00:15:43,800

The Twilight Zone.

104

00:15:51,800 --> 00:15:54,800

A pair of adults is ready to breed.

105

00:15:57,800 --> 00:16:00,800

They're both male and female.

106

00:16:01,800 --> 00:16:03,800

Hermafrodites.

107

00:16:05,800 --> 00:16:11,800

Each can produce offspring, doubling their chances of success.

108

00:16:12,800 --> 00:16:18,800

Having mated, a pentapod leaves the shelter of the canyon.

109

00:16:23,800 --> 00:16:26,800

It climbs to high ground.

110

00:16:28,800 --> 00:16:30,800

Ready to be fed.

111

00:16:32,800 --> 00:16:35,800

And the rest of the animals are ready to be fed.

112

00:16:35,800 --> 00:16:38,800

It climbs to high ground.

113

00:16:40,800 --> 00:16:42,800

Ready to spawn.

114

00:16:50,800 --> 00:16:56,800

At the top, a constant wind blows between the cold and hot sides of the planet.

115

00:17:06,800 --> 00:17:12,800

But the wind provides an opportunity to scatter their larvae.

116

00:17:19,800 --> 00:17:23,800

This way, they can colonize the planet.

117

00:17:24,800 --> 00:17:28,800

On the hot side, water is scarce.

118

00:17:32,800 --> 00:17:36,800

Condensing only in shaded areas.

119

00:17:54,800 --> 00:17:58,800

If there's nothing to eat, they move on.

120

00:18:09,800 --> 00:18:13,800

With five legs, they can skitter in any direction.

121

00:18:16,800 --> 00:18:21,800

And with ten eyes, not much escapes their attention.

122

00:18:24,800 --> 00:18:29,800

If they sense a meal, they use feelers to root it out.

123

00:18:38,800 --> 00:18:42,800

They need to make the most of every opportunity.

124

00:18:54,800 --> 00:18:58,800

Life in any desert is nordeal.

125

00:18:58,800 --> 00:19:01,800

Only the tough survive.

126

00:19:02,800 --> 00:19:08,800

And in the natural world, there's nothing much tougher than a scorpion.

127

00:19:09,800 --> 00:19:11,800

I don't think so.

128

00:19:16,800 --> 00:19:21,800

My first childhood memory of the scorpion, I was ten years old,

129

00:19:21,800 --> 00:19:24,800

and I see this big scorpion.

130

00:19:24,800 --> 00:19:27,800

It's a little bit like a scorpion.

131

00:19:27,800 --> 00:19:30,800

It's a little bit like a scorpion.

132

00:19:30,800 --> 00:19:33,800

It's a little bit like a scorpion.

133

00:19:33,800 --> 00:19:38,800

I was ten years old, and I see this big scorpion.

134

00:19:40,800 --> 00:19:42,800

I scream, Mom.

135

00:19:42,800 --> 00:19:46,800

So she came to my aid, and she was like, What? What happened?

136

00:19:46,800 --> 00:19:51,800

And I point the scorpion on the ceiling, and I said, That's gonna eat me.

137

00:19:51,800 --> 00:19:56,800

And she's like, No, come on, be cool. This is just a scorpion.

138

00:19:57,800 --> 00:20:02,800

So, as a cute Mexican mother, she took her sound to the ground.

139

00:20:03,800 --> 00:20:07,800

And she just smashed the little bastard on the ceiling.

140

00:20:16,800 --> 00:20:22,800

Carlos Santibanez Lopez is now an expert on scorpions,

141

00:20:23,800 --> 00:20:26,800

specializing in the study of their venom.

142

00:20:28,800 --> 00:20:31,800

I go at night, and I use the UV light,

143

00:20:31,800 --> 00:20:35,800

because UV light makes scorpions glow.

144

00:20:35,800 --> 00:20:38,800

They have a special protein in their shell.

145

00:20:39,800 --> 00:20:42,800

Yeah, let's take a look at this one.

146

00:20:47,800 --> 00:20:48,800

Oh, look at this.

147

00:20:48,800 --> 00:20:50,800

That's a lot of them.

148

00:20:50,800 --> 00:20:52,800

Yeah, this is great.

149

00:20:55,800 --> 00:20:59,800

Scorpions have barely changed in 400 million years.

150

00:21:01,800 --> 00:21:05,800

They're perfectly adapted for life in the desert.

151

00:21:06,800 --> 00:21:10,800

Scorpions have a very slow metabolism.

152

00:21:11,800 --> 00:21:15,800

They can spend long periods without food or water.

153

00:21:16,800 --> 00:21:22,800

We have records of some species lasting one year without eating anything.

154

00:21:24,800 --> 00:21:30,800

And they have just enough energy to sustain essential functions to keep them alive.

155

00:21:31,800 --> 00:21:37,800

They need to assure that the next time food is available, they catch it.

156

00:21:39,800 --> 00:21:45,800

Scorpions have developed a lot of weapons that they can use to hunt prey,

157

00:21:46,800 --> 00:21:51,800

including the most important weapon, venom.

158

00:22:02,800 --> 00:22:05,800

To study scorpion venom,

159

00:22:06,800 --> 00:22:10,800

Carlos needs to extract it from glands in the tail.

160

00:22:12,800 --> 00:22:19,800

Venom is a powerful cocktail that contains minerals, salts,

161

00:22:19,800 --> 00:22:23,800

and hundreds of proteins with a different function.

162

00:22:24,800 --> 00:22:27,800

Try to be as fast as you can.

163

00:22:27,800 --> 00:22:29,800

There you go.

164

00:22:29,800 --> 00:22:33,800

We use electricity to stimulate the muscles.

165

00:22:35,800 --> 00:22:40,800

We're only going to get a small, very small amount, a teeny tiny drop of it.

166

00:22:41,800 --> 00:22:45,800

But this drop is so valuable that we don't want to lose it.

167

00:22:46,800 --> 00:22:48,800

Give him a nice massage.

168

00:22:48,800 --> 00:22:51,800

Yeah, use a tiny drop.

169

00:22:51,800 --> 00:22:54,800

Oh yes, it's working. We have a venom.

170

00:22:55,800 --> 00:22:58,800

It is right there, but it's a teeny tiny drop.

171

00:22:59,800 --> 00:23:03,800

You see it? It's like a drop of water.

172

00:23:03,800 --> 00:23:06,800

Venom is such an effective weapon.

173

00:23:06,800 --> 00:23:10,800

It's used by reptiles, insects, and fish.

174

00:23:11,800 --> 00:23:16,800

It has evolved separately, at least 30 times as much as it used to.

175

00:23:17,800 --> 00:23:20,800

It's a very powerful weapon.

176

00:23:21,800 --> 00:23:24,800

It's a very powerful weapon.

177

00:23:25,800 --> 00:23:28,800

It's a very powerful weapon.

178

00:23:29,800 --> 00:23:34,800

It has evolved separately, at least 30 times.

179

00:23:38,800 --> 00:23:42,800

The more often a trait like venom has evolved on Earth,

180

00:23:43,800 --> 00:23:47,800

the more likely it is to exist on other planets.

181

00:23:59,800 --> 00:24:01,800

On the hot side of Janus,

182

00:24:02,800 --> 00:24:06,800

pentapods use venom to catch their prey.

183

00:24:15,800 --> 00:24:18,800

But hunting alone is risky.

184

00:24:29,800 --> 00:24:35,800

Even a venomous predator is powerless against a swarm.

185

00:24:53,800 --> 00:24:57,800

On the cold side of the planet, things are just as tough.

186

00:24:59,800 --> 00:25:04,800

In perpetual darkness, and with no energy from the sun,

187

00:25:06,800 --> 00:25:09,800

how can anything survive?

188

00:25:19,800 --> 00:25:23,800

On Earth, nearly all life depends on sunlight.

189

00:25:24,800 --> 00:25:28,800

Plants convert solar energy into food,

190

00:25:28,800 --> 00:25:31,800

which feeds other life forms.

191

00:25:34,800 --> 00:25:37,800

But there are some extraordinary places on Earth

192

00:25:37,800 --> 00:25:41,800

where life has evolved without any light.

193

00:25:54,800 --> 00:25:57,800

When I contemplate going in a cave like this,

194

00:25:57,800 --> 00:26:01,800

one of the things I know is that it's an alien environment.

195

00:26:02,800 --> 00:26:05,800

It is full of good ways to die.

196

00:26:06,800 --> 00:26:12,800

One of the big risks in this cave is there is a lot of hydrogen sulfide.

197

00:26:13,800 --> 00:26:15,800

Hydrogen sulfide can kill you.

198

00:26:16,800 --> 00:26:20,800

And so my husband comes along to act as a safety officer.

199

00:26:21,800 --> 00:26:24,800

He's not afraid to pull us out and say,

200

00:26:24,800 --> 00:26:27,800

time to go, you've had enough.

201

00:26:44,800 --> 00:26:46,800

Kuweva de Villaluz.

202

00:26:47,800 --> 00:26:52,800

Kuweva de Villaluz is a maze of limestone chambers.

203

00:26:56,800 --> 00:27:00,800

Hydrogen sulfide bubbles up from the Earth's crust.

204

00:27:02,800 --> 00:27:06,800

Mixing with oxygen, it forms sulfuric acid

205

00:27:06,800 --> 00:27:09,800

and turns the water milky white.

206

00:27:10,800 --> 00:27:17,800

And yet, some life forms survive and even thrive in these conditions.

207

00:27:22,800 --> 00:27:24,800

Snotite.

208

00:27:27,800 --> 00:27:30,800

Dripping colonies of bacteria.

209

00:27:30,800 --> 00:27:34,800

There are a lot of organisms in one snotite.

210

00:27:36,800 --> 00:27:39,800

Instead of relying on photosynthesis,

211

00:27:39,800 --> 00:27:43,800

they are eating hydrogen sulfide

212

00:27:43,800 --> 00:27:47,800

and are using it as their energy source.

213

00:27:47,800 --> 00:27:49,800

Okay, ready to flame?

214

00:27:49,800 --> 00:27:50,800

Yep.

215

00:27:50,800 --> 00:27:53,800

So make it nice and sterile.

216

00:27:53,800 --> 00:27:56,800

Okay, can I cap that please?

217

00:27:59,800 --> 00:28:02,800

Okay, let's go for this one.

218

00:28:02,800 --> 00:28:03,800

Okay.

219

00:28:03,800 --> 00:28:04,800

Okay.

220

00:28:04,800 --> 00:28:05,800

Okay.

221

00:28:05,800 --> 00:28:06,800

Okay.

222

00:28:06,800 --> 00:28:07,800

Okay.

223

00:28:07,800 --> 00:28:08,800

Okay.

224

00:28:08,800 --> 00:28:09,800

Okay.

225

00:28:09,800 --> 00:28:10,800

Okay.

226

00:28:10,800 --> 00:28:11,800

Okay.

227

00:28:11,800 --> 00:28:12,800

Okay.

228

00:28:12,800 --> 00:28:13,800

Okay.

229

00:28:13,800 --> 00:28:14,800

Okay.

230

00:28:14,800 --> 00:28:15,800

Okay.

231

00:28:15,800 --> 00:28:16,800

Okay.

232

00:28:16,800 --> 00:28:17,800

Okay.

233

00:28:17,800 --> 00:28:18,800

Okay.

234

00:28:18,800 --> 00:28:20,800

One snotite.

235

00:28:22,800 --> 00:28:25,800

These are some of the best snotites in the world.

236

00:28:25,800 --> 00:28:31,800

So acidic, more acidic than carb battery acid.

237

00:28:35,800 --> 00:28:41,800

An entire ecosystem has evolved to feed off the snotites.

238

00:28:42,800 --> 00:28:46,800

Creatures that have never seen daylight.

239

00:28:54,800 --> 00:28:56,800

Can you see those?

240

00:28:57,800 --> 00:28:58,800

Yes, I do.

241

00:28:59,800 --> 00:29:02,800

So there's some really big ones over here to the right.

242

00:29:04,800 --> 00:29:08,800

So whenever you see one of those white streamers of bacteria,

243

00:29:08,800 --> 00:29:11,800

you'll see a fish go after it.

244

00:29:12,800 --> 00:29:14,800

Okay, here comes some more over there.

245

00:29:14,800 --> 00:29:15,800

See?

246

00:29:15,800 --> 00:29:16,800

Here comes a big one.

247

00:29:16,800 --> 00:29:17,800

See?

248

00:29:17,800 --> 00:29:18,800

It's coming.

249

00:29:18,800 --> 00:29:20,800

There, got it.

250

00:29:23,800 --> 00:29:30,800

Studying life in total darkness has expanded how we look for life

251

00:29:30,800 --> 00:29:33,800

in other places in the universe.

252

00:29:33,800 --> 00:29:40,800

It's made us think about the fact that we could find life in places we never considered.

253

00:29:42,800 --> 00:29:43,800

There we go.

254

00:29:43,800 --> 00:29:44,800

25.

255

00:29:44,800 --> 00:29:45,800

25.

256

00:29:45,800 --> 00:29:46,800

It's getting pretty high.

257

00:29:46,800 --> 00:29:47,800

All right.

258

00:29:47,800 --> 00:29:49,800

Do you think we ought to get out of here?

259

00:29:49,800 --> 00:29:50,800

Yeah.

260

00:30:04,800 --> 00:30:07,800

All life needs some form of energy.

261

00:30:09,800 --> 00:30:13,800

On the hot face of Janus, it comes from starlight.

262

00:30:17,800 --> 00:30:21,800

On the cold face, it comes from deep within.

263

00:30:28,800 --> 00:30:30,800

Geothermal activity.

264

00:30:34,800 --> 00:30:43,800

When volcanic pressure forces water to the surface, there's a flurry of new life,

265

00:30:44,800 --> 00:30:47,800

which stirs pentapods into action.

266

00:30:47,800 --> 00:30:49,800

There are some new life forms.

267

00:30:49,800 --> 00:30:54,800

They're after grubs that emerge around geothermal pools,

268

00:30:58,800 --> 00:31:00,800

but it's not so easy.

269

00:31:01,800 --> 00:31:04,800

The grubs have evolved a defense.

270

00:31:04,800 --> 00:31:08,800

They jump and flash a warning signal to others,

271

00:31:10,800 --> 00:31:13,800

acting as one to stay alive.

272

00:31:15,800 --> 00:31:17,800

The grubs are now in the air.

273

00:31:17,800 --> 00:31:19,800

They're in the air.

274

00:31:19,800 --> 00:31:21,800

They're in the air.

275

00:31:21,800 --> 00:31:23,800

They're in the air.

276

00:31:23,800 --> 00:31:25,800

They're in the air.

277

00:31:25,800 --> 00:31:27,800

They're in the air.

278

00:31:27,800 --> 00:31:30,800

And there's one to stay alive.

279

00:31:46,800 --> 00:31:50,800

On Earth, some animals use light in the same way.

280

00:31:51,800 --> 00:31:53,800

To send signals.

281

00:31:58,800 --> 00:32:02,800

Every single point of light that you see out there is a firefly.

282

00:32:04,800 --> 00:32:07,800

Right as the sun sets, you'll start to see them come up.

283

00:32:08,800 --> 00:32:10,800

Like little sparks rising from a fire.

284

00:32:10,800 --> 00:32:12,800

It's just spectacular.

285

00:32:12,800 --> 00:32:15,800

And then only gets better as the night gets darker.

286

00:32:23,800 --> 00:32:26,800

Fireflies flash as a form of energy.

287

00:32:27,800 --> 00:32:29,800

They're a communication.

288

00:32:29,800 --> 00:32:32,800

They are among the only land animals

289

00:32:32,800 --> 00:32:35,800

that communicate with light of their own making.

290

00:32:38,800 --> 00:32:44,800

Bioluminescence evolved among fireflies as a warning to predators

291

00:32:44,800 --> 00:32:49,800

that they're packed with toxins and should be given a wide berth.

292

00:32:49,800 --> 00:32:53,800

Now the same mechanism is used for finding a mate.

293

00:32:57,800 --> 00:33:03,800

So the firefly produces light from an organ on its abdomen called the lantern.

294

00:33:03,800 --> 00:33:08,800

And this organ has an enzyme that produces one photon of light.

295

00:33:08,800 --> 00:33:10,800

This chemical reaction involves oxygen.

296

00:33:10,800 --> 00:33:13,800

So by controlling the flow of oxygen to their lantern,

297

00:33:13,800 --> 00:33:16,800

they can produce a single photon of light.

298

00:33:16,800 --> 00:33:20,800

And by using oxygen to their lantern, they can produce flashes.

299

00:33:20,800 --> 00:33:22,800

They can turn the chemical reaction on and off

300

00:33:22,800 --> 00:33:26,800

and use these flashes to communicate with each other.

301

00:33:35,800 --> 00:33:39,800

The males are flying around and they're doing little advertisements,

302

00:33:39,800 --> 00:33:42,800

little flashes that say, here I am, this is me, check me out.

303

00:33:43,800 --> 00:33:48,800

And then the females are waiting on the ground below and they're looking up.

304

00:33:50,800 --> 00:33:54,800

And when they see a guy that they like, they flash back.

305

00:33:56,800 --> 00:34:00,800

And then the male will come over, he'll flash again, she flashes back,

306

00:34:00,800 --> 00:34:02,800

and they come together and mate.

307

00:34:02,800 --> 00:34:09,800

So this is actually one big flirtatious dance that we're seeing right here behind us.

308

00:34:12,800 --> 00:34:17,800

Each species creates its own little language that they can use to find each other in the dark.

309

00:34:19,800 --> 00:34:23,800

But using light to communicate is inherently risky.

310

00:34:25,800 --> 00:34:30,800

Some species have evolved to emit fake signals.

311

00:34:34,800 --> 00:34:40,800

What we have here is a predatory, futuristic female, also called femme fatale,

312

00:34:40,800 --> 00:34:46,800

because they have a reputation for luring in males of other species to eat them.

313

00:34:46,800 --> 00:34:53,800

They can hack into the communication between a male and a female and use that to her advantage.

314

00:34:55,800 --> 00:35:02,800

So you can tell this is a predatory firefly because her lantern has a different shape to it.

315

00:35:02,800 --> 00:35:07,800

Only two little lines light up, almost like an equal sign.

316

00:35:07,800 --> 00:35:11,800

So basically a male will be flying around looking for a mate,

317

00:35:11,800 --> 00:35:17,800

and then when the males flash, they flash back just as if they were a female of that species.

318

00:35:17,800 --> 00:35:21,800

So they're imitating the females of that other species to get the male to come over.

319

00:35:21,800 --> 00:35:24,800

But they don't want to mate with that male.

320

00:35:24,800 --> 00:35:27,800

She wants to eat that male.

321

00:35:29,800 --> 00:35:34,800

And she proceeds to do so in an extremely violent way.

322

00:35:38,800 --> 00:35:43,800

This is a classic example of a predator using mimicry.

323

00:35:47,800 --> 00:35:53,800

One species copying the behavior of another in order to kill it.

324

00:35:58,800 --> 00:36:03,800

Lying in the sea is pretty widespread in the animal kingdom, I would say.

325

00:36:04,800 --> 00:36:07,800

And I think it would be on any planet.

326

00:36:22,800 --> 00:36:26,800

On Janus, the grubs use light to stay alive.

327

00:36:27,800 --> 00:36:32,800

But their system is about to be hacked.

328

00:36:44,800 --> 00:36:49,800

By catching a few grubs, the pentapods absorb their bioluminescence

329

00:36:50,800 --> 00:36:55,800

and mimic their warning signals.

330

00:36:58,800 --> 00:37:03,800

The grubs instinctively jump away from flashing lights.

331

00:37:04,800 --> 00:37:09,800

But this time, it's a trap.

332

00:37:09,800 --> 00:37:14,800

The pentapods have them where they want them.

333

00:37:15,800 --> 00:37:20,800

Again, adaptability is the secret to their survival.

334

00:37:30,800 --> 00:37:36,800

But for all creatures on Janus, the grubs are not the only ones who can do it.

335

00:37:36,800 --> 00:37:40,800

They are the ones who can do it.

336

00:37:44,800 --> 00:37:49,800

Existence depends on one key ingredient.

337

00:37:52,800 --> 00:37:56,800

Whether in the hot, cold or twilight worlds.

338

00:37:59,800 --> 00:38:01,800

Water.

339

00:38:15,800 --> 00:38:20,800

Everybody knows the story of Goldilocks and the three bears.

340

00:38:22,800 --> 00:38:27,800

She sneaks into their house and tries to hit their porridge.

341

00:38:30,800 --> 00:38:33,800

The first ball is too hot.

342

00:38:36,800 --> 00:38:40,800

The second ball is freezing cold.

343

00:38:45,800 --> 00:38:50,800

It's only when she tries the third ball that she's happy.

344

00:38:53,800 --> 00:38:58,800

This one, Goldilocks says, is just right.

345

00:39:00,800 --> 00:39:07,800

When we look around the universe in the search for life, we are looking for conditions that are just right.

346

00:39:08,800 --> 00:39:14,800

And just right in this case, is defined by the presence of this stuff.

347

00:39:14,800 --> 00:39:16,800

Water.

348

00:39:22,800 --> 00:39:27,800

Water transports the essentials for life around the planet.

349

00:39:29,800 --> 00:39:32,800

And around every living body.

350

00:39:33,800 --> 00:39:37,800

It's the most important substance in the universe.

351

00:39:51,800 --> 00:39:58,800

Because water is so familiar to us, it's not until you really stop and think about it that you realize how weird it is.

352

00:39:59,800 --> 00:40:06,800

Water is made up by one oxygen atom and two hydrogen atoms.

353

00:40:07,800 --> 00:40:15,800

And because of the nature of the elements and the way they're bound, we have a net negative charge at the oxygen side and positive on the two hydrogen.

354

00:40:15,800 --> 00:40:22,800

This means that every hydrogen in a molecule can interact with the oxygen on the other molecules neighboring.

355

00:40:22,800 --> 00:40:30,800

And that's why we have to replicate this attraction for billions of neighboring molecules and you get a substance that is very sticky.

356

00:40:31,800 --> 00:40:38,800

And water molecules don't just attract each other, they attract to almost any other molecule they come in contact with.

357

00:40:40,800 --> 00:40:46,800

They pull other substances apart, break them down and dissolve them.

358

00:40:53,800 --> 00:41:01,800

Water is the universal solvent because of its unique ability to dissolve nutrients and chemicals.

359

00:41:13,800 --> 00:41:19,800

It seems certain the first spark of life on Earth happened not on land.

360

00:41:19,800 --> 00:41:23,800

But in water.

361

00:41:29,800 --> 00:41:36,800

Deep underwater in the primordial oceans, the chemical ingredients for life were swirling around.

362

00:41:37,800 --> 00:41:42,800

What was needed was a place to concentrate these ingredients.

363

00:41:43,800 --> 00:41:48,800

To allow the chemical reaction that would eventually lead to life.

364

00:41:50,800 --> 00:41:55,800

That place could have been a hydrothermal vent.

365

00:41:58,800 --> 00:42:08,800

Water interacts with hot rocks deep underground and comes gushing back up into the freezing sea water carrying nutrients and chemicals.

366

00:42:09,800 --> 00:42:13,800

Little bubbles of life.

367

00:42:16,800 --> 00:42:20,800

The link between water and life is so strong.

368

00:42:21,800 --> 00:42:27,800

It's hard to imagine any life anywhere in the universe existing without it.

369

00:42:28,800 --> 00:42:33,800

It's mind-boggling to think how life can find a way in very extreme places.

370

00:42:33,800 --> 00:42:35,800

Very hot, very cold.

371

00:42:35,800 --> 00:42:37,800

And at the end is all about the water.

372

00:42:37,800 --> 00:42:40,800

If there's liquid water, you'll find life.

373

00:42:58,800 --> 00:43:02,800

Water on Janus is scarce.

374

00:43:04,800 --> 00:43:07,800

It either freezes as ice,

375

00:43:10,800 --> 00:43:13,800

or evaporates into the wind.

376

00:43:17,800 --> 00:43:22,800

But there's just enough liquid water for life to take hold.

377

00:43:23,800 --> 00:43:30,800

And for the toughest of creatures to adapt and survive.

378

00:43:41,800 --> 00:43:44,800

At NASA, they have a saying,

379

00:43:44,800 --> 00:43:49,800

if you want to find life, follow the water.

380

00:43:53,800 --> 00:43:58,800

How might life adapt on a different world?

381

00:43:59,800 --> 00:44:01,800

One with two stars.

382

00:44:04,800 --> 00:44:08,800

Where there's more energy than on Earth.

383

00:44:11,800 --> 00:44:15,800

A planet perfect for life.

384

00:44:52,800 --> 00:44:55,800

NASA

385

00:45:22,800 --> 00:45:25,800

You