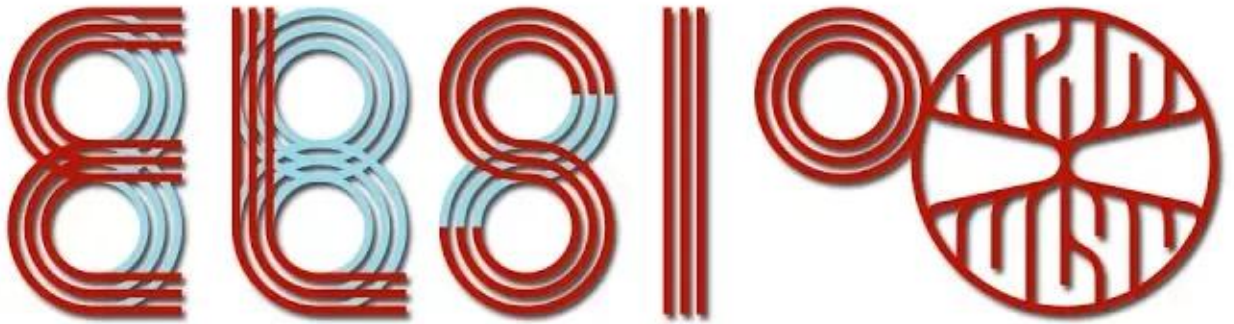

EARTH-LIFE
SCIENCE
INSTITUTE

Jennifer Hoyal Cuthill

The origin of animals

1
00:00:16,209 --> 00:00:12,629
[Music]

2
00:00:19,690 --> 00:00:16,219
good afternoon my name is Jennifer I am

3
00:00:23,290 --> 00:00:19,700
a paleo biologist and a research fellow

4
00:00:26,560 --> 00:00:23,300
here at LC and also at University of

5
00:00:29,890 --> 00:00:26,570
Cambridge in the UK and I'd like to talk

6
00:00:33,120 --> 00:00:29,900
to you now about the evolutionary origin

7
00:00:36,520 --> 00:00:33,130
of the animals including us

8
00:00:40,000 --> 00:00:36,530
so the eon of time which we live in

9
00:00:43,690 --> 00:00:40,010
today it's called the phanerozoic this

10
00:00:44,500 --> 00:00:43,700
means visible life or literally visible

11
00:00:49,810 --> 00:00:44,510
animals

12
00:00:53,970 --> 00:00:49,820
this began 541 million years ago in the

13
00:00:57,400 --> 00:00:53,980

Cambrian period this is the time when

14
00:01:01,030 --> 00:00:57,410
many of the modern animal groups first

15
00:01:04,000 --> 00:01:01,040
appear in the fossil record you can see

16
00:01:05,380 --> 00:01:04,010
some examples of these up here so this

17
00:01:08,080 --> 00:01:05,390
is a time when there was a great

18
00:01:11,620 --> 00:01:08,090
increase in the diversity of life and

19
00:01:13,719 --> 00:01:11,630
this is called the Cambrian explosion so

20
00:01:16,840 --> 00:01:13,729
what led to the Cambrian explosion

21
00:01:19,330 --> 00:01:16,850
why did this happen at that time to

22
00:01:22,359 --> 00:01:19,340
understand this we need to look back at

23
00:01:25,029 --> 00:01:22,369
the geological record of life just

24
00:01:29,560 --> 00:01:25,039
before this in the proterozoic eon

25
00:01:32,260 --> 00:01:29,570
meaning earlier life at this time the

26
00:01:35,800 --> 00:01:32,270
planet was quite different from that of

27
00:01:39,370 --> 00:01:35,810
today levels of oxygen in the atmosphere

28
00:01:43,120 --> 00:01:39,380
and the oceans began to rise from

29
00:01:45,700 --> 00:01:43,130
initially very low levels and the oceans

30
00:01:48,940 --> 00:01:45,710
may still have been quite toxic to

31
00:01:52,569 --> 00:01:48,950
modern animals with very low levels of

32
00:01:58,319 --> 00:01:52,579
oxygen and high levels of iron and

33
00:02:02,249 --> 00:01:58,329
sulfur life forms were still microscopic

34
00:02:06,370 --> 00:02:02,259
such as photosynthetic cyanobacteria

35
00:02:10,029 --> 00:02:06,380
whose colonies form mounds called

36
00:02:12,940 --> 00:02:10,039
stromatolites at the edge of the sea but

37
00:02:16,270 --> 00:02:12,950
at this time no plants or animals were

38
00:02:19,059 --> 00:02:16,280

yet living on the land so let's

39
00:02:23,410 --> 00:02:19,069
a closer look at life in the proterozoic

40
00:02:27,040 --> 00:02:23,420
eon this is a microfossil very small

41
00:02:30,370 --> 00:02:27,050
fossil called Fangio morpha this is

42
00:02:33,520 --> 00:02:30,380
thought to be a type of red algae and so

43
00:02:37,780 --> 00:02:33,530
a relative of plants and this is from

44
00:02:41,110 --> 00:02:37,790
around 1.2 billion years ago fossils

45
00:02:44,100 --> 00:02:41,120
like man geomorphic show that life forms

46
00:02:47,340 --> 00:02:44,110
had already evolved multicellularity

47
00:02:51,400 --> 00:02:47,350
many cells in their body by this time

48
00:02:51,910 --> 00:02:51,410
but they were still very small for

49
00:02:54,729 --> 00:02:51,920
example

50
00:02:58,020 --> 00:02:54,739
Mangiamo fur was less than one

51
00:03:02,410 --> 00:02:58,030
millimeter long and very thin

52
00:03:05,170 --> 00:03:02,420
later in the Proterozoic we have a

53
00:03:09,220 --> 00:03:05,180
geological period called the cryogenian

54
00:03:11,890 --> 00:03:09,230
which means cold birth during this time

55
00:03:14,770 --> 00:03:11,900
the planet experienced some of the

56
00:03:17,710 --> 00:03:14,780
greatest changes in climate but has ever

57
00:03:23,020 --> 00:03:17,720
had in its history there were at least

58
00:03:25,210 --> 00:03:23,030
two massive glaciations ice ages that

59
00:03:28,509 --> 00:03:25,220
covered much of the surface of the

60
00:03:32,470 --> 00:03:28,519
planet in ice and each lasted for

61
00:03:35,800 --> 00:03:32,480
millions of years these glaciations were

62
00:03:39,910 --> 00:03:35,810
so severe that they are called snowball

63
00:03:43,680 --> 00:03:39,920

earth events these may have restricted

64
00:03:46,530 --> 00:03:43,690
the abundance of many life forms

65
00:03:50,940 --> 00:03:46,540
including the photosynthetic

66
00:03:53,860 --> 00:03:50,950
microorganisms which produce oxygen and

67
00:03:57,819 --> 00:03:53,870
form the base of the food chain for

68
00:04:00,340 --> 00:03:57,829
everything else but life survived the

69
00:04:02,849 --> 00:04:00,350
snowball earth events and there are

70
00:04:06,220 --> 00:04:02,859
fossils from the cryogenian period

71
00:04:09,910 --> 00:04:06,230
these include mysterious circles in the

72
00:04:12,400 --> 00:04:09,920
rock such as the twitcher discs which

73
00:04:16,420 --> 00:04:12,410
are from the Twitter rock formation in

74
00:04:20,140 --> 00:04:16,430
lymph Kensie mountains from Canada these

75
00:04:23,500 --> 00:04:20,150
are around one centimeter wide and they

76
00:04:28,120 --> 00:04:23,510
may perhaps be simple relatives of

77
00:04:31,350 --> 00:04:28,130
animals but this simplicity may

78
00:04:35,760 --> 00:04:31,360
that they could instead be colonies of

79
00:04:40,300 --> 00:04:35,770
microorganisms rather bacteria or

80
00:04:43,900 --> 00:04:40,310
microalgae and not animals at all as

81
00:04:48,090 --> 00:04:43,910
well as fossils of animal and plant

82
00:04:52,000 --> 00:04:48,100
bodies ancient rocks can also preserve

83
00:04:56,410 --> 00:04:52,010
molecular fossils these are also known

84
00:04:58,690 --> 00:04:56,420
as biomarkers these are molecules which

85
00:05:04,200 --> 00:04:58,700
are known to be produced by living

86
00:05:07,600 --> 00:05:04,210
groups such as animals like sponges

87
00:05:12,030 --> 00:05:07,610
sponge biomarkers like this molecule

88
00:05:16,450 --> 00:05:12,040

here have been found in cryogenian rocks

89
00:05:16,990 --> 00:05:16,460
which are more than 635 million years

90
00:05:22,030 --> 00:05:17,000
old

91
00:05:25,330 --> 00:05:22,040
this suggests that sponges which are the

92
00:05:29,620 --> 00:05:25,340
most ancient of the living animals had

93
00:05:34,200 --> 00:05:29,630
evolved by this time so where are they

94
00:05:38,680 --> 00:05:34,210
in the fossil record this tiny fossil is

95
00:05:42,550 --> 00:05:38,690
less than one millimeter wide yet it is

96
00:05:45,520 --> 00:05:42,560
similar in shape to simple sponges that

97
00:05:48,130 --> 00:05:45,530
are still alive today with a central

98
00:05:50,500 --> 00:05:48,140
opening like those you can see here

99
00:05:53,560 --> 00:05:50,510
which may have functioned to draw

100
00:05:57,550 --> 00:05:53,570
through water as it fed on small

101
00:06:00,880 --> 00:05:57,560
particles from the water flow this could

102
00:06:03,550 --> 00:06:00,890
suggest that sponges had indeed evolved

103
00:06:07,420 --> 00:06:03,560
by this time that the animals had begun

104
00:06:10,860 --> 00:06:07,430
to diversify but they were still mostly

105
00:06:14,340 --> 00:06:10,870
very small and so very rare to fossilize

106
00:06:18,190 --> 00:06:14,350
at the end of the snowball earth events

107
00:06:22,360 --> 00:06:18,200
we enter a new geological period the

108
00:06:24,910 --> 00:06:22,370
Ediacaran period running from 635

109
00:06:29,800 --> 00:06:24,920
million years ago up to the Cambrian

110
00:06:32,440 --> 00:06:29,810
boundary at 541 million years ago during

111
00:06:35,500 --> 00:06:32,450
this time the earth became more

112
00:06:39,190 --> 00:06:35,510
hospitable to animals with a warmer

113
00:06:39,709 --> 00:06:39,200

climate and potentially an increase in

114
00:06:43,070 --> 00:06:39,719
the above

115
00:06:47,179 --> 00:06:43,080
of microorganisms those microorganisms

116
00:06:52,309 --> 00:06:47,189
that produce oxygen as well as food for

117
00:06:55,309 --> 00:06:52,319
animals some Ediacaran rocks such as

118
00:06:59,839 --> 00:06:55,319
these from Newfoundland Canada show

119
00:07:02,479 --> 00:06:59,849
changes in color from red to grey that

120
00:07:05,899 --> 00:07:02,489
are due to changes in the chemistry of

121
00:07:08,600 --> 00:07:05,909
iron in the rock this shows that at

122
00:07:11,659 --> 00:07:08,610
least here at this time there were

123
00:07:13,819 --> 00:07:11,669
increases in the level of oxygen so

124
00:07:17,829 --> 00:07:13,829
there is another rise in the amount of

125
00:07:22,399 --> 00:07:17,839
oxygen in the ocean right at this time

126
00:07:25,759 --> 00:07:22,409
this increase in oxygen may have allowed

127
00:07:28,699 --> 00:07:25,769
life forms such as early animals to

128
00:07:32,989 --> 00:07:28,709
reach large size to grow to new sizes

129
00:07:36,169 --> 00:07:32,999
not seen in life before this is because

130
00:07:39,799 --> 00:07:36,179
large animals like us need lots of

131
00:07:45,129 --> 00:07:39,809
oxygen in order to gain energy from our

132
00:07:49,100 --> 00:07:45,139
food by respiration from this time a

133
00:07:51,799 --> 00:07:49,110
wide range of large life forms appear in

134
00:07:55,759 --> 00:07:51,809
the fossil record these are known as the

135
00:07:58,189 --> 00:07:55,769
Ediacaran biota some of these look a

136
00:08:01,279 --> 00:07:58,199
little like living animals like this

137
00:08:04,629 --> 00:08:01,289
fossil creature called Spragg ina at the

138
00:08:08,239 --> 00:08:04,639

bottom here others look more unusual

139
00:08:09,799 --> 00:08:08,249
such as these rangaiah moths the group

140
00:08:13,129 --> 00:08:09,809
which I work on myself

141
00:08:16,999 --> 00:08:13,139
these had bodies that were made up of

142
00:08:20,869 --> 00:08:17,009
many small branches this type of shape

143
00:08:24,139 --> 00:08:20,879
is known as a fractal meaning broken

144
00:08:26,809 --> 00:08:24,149
shape and this reconstruction here was

145
00:08:31,219 --> 00:08:26,819
computer generated using a fractal

146
00:08:34,399 --> 00:08:31,229
algorithm Rangi moths are named after a

147
00:08:37,459 --> 00:08:34,409
fossil could rangayya which you can see

148
00:08:40,610 --> 00:08:37,469
in this example here with exceptionally

149
00:08:43,660 --> 00:08:40,620
preserved branches rangaiah was

150
00:08:47,389 --> 00:08:43,670
discovered in namibia africa in the

151
00:08:51,490 --> 00:08:47,399
early 20th century among the rocks of

152
00:08:52,879 --> 00:08:51,500
this beautiful but dry landscape

153
00:08:55,999 --> 00:08:52,889
geologically

154
00:08:59,590 --> 00:08:56,009
these fossils from Namibia are among the

155
00:09:03,889 --> 00:08:59,600
younger members of the Ediacaran biota

156
00:09:07,929 --> 00:09:03,899
the very oldest of these large Ediacaran

157
00:09:10,840 --> 00:09:07,939
fossils are found in Newfoundland Canada

158
00:09:14,179 --> 00:09:10,850
such as these beds of fossils at

159
00:09:17,389 --> 00:09:14,189
mistaken point which is now a world

160
00:09:20,479 --> 00:09:17,399
heritage site these beds are covered in

161
00:09:24,739 --> 00:09:20,489
fossils which you can see here as pale

162
00:09:26,840 --> 00:09:24,749
lines all over the rock if we look in

163
00:09:29,679 --> 00:09:26,850

close up at some of these fossils from

164
00:09:32,509 --> 00:09:29,689
Newfoundland we can see that here

165
00:09:35,049 --> 00:09:32,519
Ediacaran fossils are preserved as faint

166
00:09:38,900 --> 00:09:35,059
impressions on the surface of the rock

167
00:09:42,289 --> 00:09:38,910
some of these are really very large such

168
00:09:45,349 --> 00:09:42,299
as this fossil called Tripathy which is

169
00:09:48,619 --> 00:09:45,359
a few centimetres wide but more than one

170
00:09:52,549 --> 00:09:48,629
metre long extending like a ribbon along

171
00:09:55,789 --> 00:09:52,559
the rock among these strange forms are

172
00:09:59,030 --> 00:09:55,799
some others which look more like living

173
00:10:03,350 --> 00:09:59,040
animals such as this triangular fossil

174
00:10:06,799 --> 00:10:03,360
with in here called effect Ardis this

175
00:10:10,009 --> 00:10:06,809
may be an impression of a simple sponge

176
00:10:14,539 --> 00:10:10,019
of a similar shape to the ones we see

177
00:10:17,840 --> 00:10:14,549
today the Ediacaran period is named

178
00:10:21,400 --> 00:10:17,850
after another important fossil site in

179
00:10:24,949 --> 00:10:21,410
the ediacara hills of south australia

180
00:10:28,189 --> 00:10:24,959
Ediacaran fossils from australia include

181
00:10:30,979 --> 00:10:28,199
other mysterious types such as this

182
00:10:34,999 --> 00:10:30,989
large fossil called Dickon Sonja with

183
00:10:37,009 --> 00:10:35,009
many fine branches or segments as well

184
00:10:39,769 --> 00:10:37,019
as others like this small fossil here

185
00:10:42,919 --> 00:10:39,779
called Pavan Khurana which is the shape

186
00:10:45,439 --> 00:10:42,929
of the English letter T rocks from

187
00:10:47,389 --> 00:10:45,449
Australia preserved the transition all

188
00:10:51,439 --> 00:10:47,399

the way through the Ediacaran to the

189
00:10:53,840 --> 00:10:51,449
Cambrian among these fossils are small

190
00:10:56,779 --> 00:10:53,850
burrows which show the traces of

191
00:11:00,650 --> 00:10:56,789
movement on and through the sediment of

192
00:11:03,230 --> 00:11:00,660
the sea floor these fossils show that by

193
00:11:07,040 --> 00:11:03,240
the late edie Akron active

194
00:11:10,280 --> 00:11:07,050
moving animals had evolved as we move

195
00:11:13,579 --> 00:11:10,290
into the Cambrian period worldwide we

196
00:11:17,720 --> 00:11:13,589
see many more fossils of active moving

197
00:11:20,660 --> 00:11:17,730
animals such as this fossil called gali

198
00:11:23,630 --> 00:11:20,670
octina which looks very similar to

199
00:11:26,960 --> 00:11:23,640
modern tena fours also known as comb

200
00:11:29,500 --> 00:11:26,970
jellies this fossil is from Chang Jiang

201
00:11:32,090 --> 00:11:29,510
in China a famous place where

202
00:11:34,790 --> 00:11:32,100
exceptional fossils of soft bodied

203
00:11:37,100 --> 00:11:34,800
animals like this can be found although

204
00:11:41,060 --> 00:11:37,110
these are otherwise rare in the fossil

205
00:11:43,730 --> 00:11:41,070
record another place where exceptional

206
00:11:46,160 --> 00:11:43,740
Cambrian fossils have been found is the

207
00:11:49,670 --> 00:11:46,170
Burgess Shale in the Canadian Rocky

208
00:11:53,060 --> 00:11:49,680
Mountains these fossils include

209
00:11:56,570 --> 00:11:53,070
relatives of modern arthropods the group

210
00:12:00,470 --> 00:11:56,580
which includes shrimp crabs and insects

211
00:12:03,550 --> 00:12:00,480
today these fossils include this large

212
00:12:06,829 --> 00:12:03,560
predator called anomalocaris this

213
00:12:10,760 --> 00:12:06,839

dangerous animal was up to a meter long

214
00:12:14,110 --> 00:12:10,770
and had huge claws in front of its mouth

215
00:12:17,980 --> 00:12:14,120
for catching prey what was it eating

216
00:12:21,680 --> 00:12:17,990
well among Cambrian fossils are also

217
00:12:23,690 --> 00:12:21,690
small fish like animals such as this

218
00:12:27,139 --> 00:12:23,700
fossil from the Burgess Shale called

219
00:12:30,710 --> 00:12:27,149
pacaya the kaya was an active swimming

220
00:12:34,280 --> 00:12:30,720
animal with a head that had sense organs

221
00:12:39,350 --> 00:12:34,290
and a nerve cord which ran along its

222
00:12:41,780 --> 00:12:39,360
back these features show that pacaya was

223
00:12:45,889 --> 00:12:41,790
a distant relative of vertebrates

224
00:12:48,050 --> 00:12:45,899
animals with backbones like us fossils

225
00:12:50,449 --> 00:12:48,060
like pacaya tell us that some of the

226
00:12:54,230 --> 00:12:50,459
most important human features like our

227
00:12:57,800 --> 00:12:54,240
brain have evolutionary origins among

228
00:13:05,850 --> 00:12:57,810
very early animals of the Cambrian more

229
00:13:24,050 --> 00:13:06,910
[Applause]

230
00:13:24,060 --> 00:13:38,730
[Music]