

1	00:03:53:26	00:03:57:08	Annenberg Media
2	00:03:57:10	00:04:49:05	§
3	00:04:49:07	00:04:50:20	OUR PLANET IS TEEMING
4	00:04:50:22	00:04:53:11	WITH A TREMENDOUS
			DIVERSITY OF LIFE FORMS,
5	00:04:53:13	00:04:57:00	AND EACH YEAR MANY NEW
			SPECIES ARE DISCOVERED.
6	00:04:57:02	00:04:58:16	THERE IS MUCH TO LEARN
7	00:04:58:18	00:05:00:14	ABOUT HOW THIS
			LIVING WORLD EVOLVED,
8	00:05:00:16	00:05:02:15	YET FOSSIL EVIDENCE
			OF EARLIEST LIFE
9	00:05:02:17	00:05:04:29	SUGGESTS A WORLD
			ONCE DOMINATED
10	00:05:05:01	00:05:06:15	BY MICROSCOPIC
			ORGANISMS.
11	00:05:06:17	00:05:09:00	HOW THE PRESENT
			VARIETY OF LIFE
12	00:05:09:02	00:05:10:17	EVOLVED THROUGH TIME
13	00:05:10:19	00:05:13:08	REMAINS ONE
			OF THE MOST INTRIGUING ISSUES
14	00:05:13:10	00:05:14:27	IN SCIENCE.
15	00:05:16:24	00:05:18:05	THIS IS ALGAE,
16	00:05:18:07	00:05:20:20	ONE OF THE SIMPLEST
			ORGANISMS ON EARTH,
17	00:05:20:22	00:05:23:07	AND IT'S BEEN AROUND
			AN EXTREMELY LONG TIME.
18	00:05:23:09	00:05:24:22	FROM FOSSIL EVIDENCE,
19	00:05:24:24	00:05:27:06	WE KNOW THAT ALGAE
			HAS BEEN ON EARTH
20	00:05:27:08	00:05:29:00	AT LEAST
			1.8 BILLION YEARS.
21	00:05:29:02	00:05:30:22	OLDER AND MORE
			PRIMITIVE ORGANISMS
22	00:05:30:24	00:05:33:29	HAVE BEEN FOUND IN ROCKS
			FROM ALL OVER THE WORLD.
23	00:05:34:01	00:05:35:09	THE PROBABLE
			FOSSIL REMAINS
24	00:05:35:11	00:05:37:08	OF BLUE-GREEN ALGAE
			AND BACTERIA
25	00:05:37:10	00:05:38:25	HAVE BEEN FOUND IN ROCKS
26	00:05:38:27	00:05:40:07	NEARLY 3 BILLION
			YEARS OLD
27	00:05:40:09	00:05:41:22	IN AUSTRALIA, AFRICA,
28	00:05:41:24	00:05:44:02	AND EVEN HERE
			IN NORTH AMERICA.
29	00:05:44:04	00:05:46:18	THE STUDY OF FOSSILS
			HAS ENABLED SCIENTISTS
30	00:05:46:20	00:05:49:02	TO IDENTIFY THOUSANDS OF
			SPECIES OF PLANTS AND ANIMALS
31	00:05:49:04	00:05:51:05	THAT ONCE INHABITED
			THE EARTH.
32	00:05:51:07	00:05:53:20	BUT THE PICTURE OF ANCIENT LIFE
			IS FAR FROM COMPLETE,
33	00:05:53:22	00:05:55:26	ESPECIALLY OUR UNDERSTANDING
			OF LIFE'S ORIGINS.

34 00:05:55:28 00:05:57:25 SCIENTISTS HAVE
 AN ENORMOUS CHALLENGE
 35 00:05:57:27 00:06:00:24 TO FILL OUR GAPS OF KNOWLEDGE
 IN LIFE'S HISTORY.
 36 00:06:00:26 00:06:02:21 A GOOD WAY TO START
 37 00:06:02:23 00:06:04:21 IS TO GO
 TO THE ROCKS THEMSELVES
 38 00:06:04:23 00:06:06:14 AND LITERALLY DIG
 FOR CLUES.
 39 00:06:08:07 00:06:09:20 *THESE CLUES EXIST*
 40 00:06:09:22 00:06:12:20 *IN THE FOSSILIZED*
REMAINS OF PAST LIFE.
 41 00:06:12:22 00:06:15:20 *FOSSILS CAN BE FORMED*
IN SEVERAL WAYS.
 42 00:06:15:22 00:06:18:11 *AFTER SOME ORGANISMS DIE,*
 43 00:06:18:13 00:06:21:06 *THEY ARE QUICKLY BURIED*
BY SEDIMENT.
 44 00:06:21:08 00:06:23:06 *AS THE SEDIMENT*
URNS TO STONE,
 45 00:06:23:08 00:06:25:00 *THE REMAINS DECAY*
OR DISSOLVE,
 46 00:06:25:02 00:06:28:00 *AND A HOLLOW CAVITY*
ALLED A MOLD
 47 00:06:28:02 00:06:29:16 *IS LEFT BEHIND.*
 48 00:06:29:18 00:06:32:13 *MOLDS ARE AMONG*
THE MOST COMMON FOSSILS,
 49 00:06:32:15 00:06:35:14 *BUT OTHER TYPES*
ALSO OCCUR IN ABUNDANCE.
 50 00:06:35:16 00:06:37:21 *BURIED BONE*
AND SHELL MATERIAL
 51 00:06:37:23 00:06:41:00 *MAY SURVIVE INTACT*
WITHIN SEDIMENTARY ROCK
 52 00:06:41:02 00:06:42:22 *FOR MILLIONS OF YEARS.*
 53 00:06:42:24 00:06:45:04 *HOWEVER, MUCH OF THIS*
MATERIAL CRYSTALLIZES
 54 00:06:45:06 00:06:46:20 *OR IS REPLACED*
 55 00:06:46:22 00:06:49:08 *BY MINERALS DEPOSITED*
FROM GROUND WATER.
 56 00:06:49:10 00:06:51:29 *CASTS PRESERVING*
THE ORIGINAL FORMS
 57 00:06:52:01 00:06:53:21 *OF THE ORGANISM RESULT.*
 58 00:06:53:23 00:06:56:05 *LIKE MOLDS,*
CASTS ARE NUMEROUS.
 59 00:06:57:12 00:06:58:25 *EVIDENCE SHOWING*
THE ACTIVITY
 60 00:06:58:27 00:07:01:18 *OF PAST ORGANISMS*
IS ALSO FOUND
 61 00:07:01:20 00:07:05:10 *IN THE FORM OF FOSSIL*
TRACKS, BURROWS, AND NESTS.
 62 00:07:06:25 00:07:09:06 *THAT FOSSILS EXIST*
AT ALL IS STARTLING
 63 00:07:09:08 00:07:11:20 *CONSIDERING THE VIGOROUS*
PROCESSES OF EROSION
 64 00:07:11:22 00:07:15:03 *AND PLATE TECTONICS ACTING*
ON EARTH'S SURFACE.
 65 00:07:15:05 00:07:16:27 *THE PRESERVATION*

66 00:07:16:29 OF FOSSILS
 00:07:19:13 IS PROBABLY BEST
 IN THE OCEAN
 67 00:07:19:15 00:07:22:12 WHERE YOU HAVE
 A SUPERABUNDANCE
 OF ORGANISMS,
 68 00:07:22:14 00:07:25:23 SO THAT WHEN YOU HAVE
 MANY MILLIONS
 OF LITTLE CRITTERS
 69 00:07:25:25 00:07:28:04 THAT CAN FALL
 TO THE SEA FLOOR,
 70 00:07:28:06 00:07:30:22 MANY TENS OR EVEN
 HUNDRED OR THOUSANDS
 71 00:07:30:24 00:07:32:19 MAY BE PRESERVED.
 72 00:07:32:21 00:07:34:18 SO PROBABLY
 OUR BEST FOSSIL RECORD
 73 00:07:34:20 00:07:36:18 COMES FROM MARINE
 SEDIMENTARY ROCKS
 74 00:07:36:20 00:07:38:21 WHERE THE ORGANISMS
 ARE SMALL
 75 00:07:38:23 00:07:41:18 AND THE CHANCES FOR
 PRESERVATION ARE BEST.
 76 00:07:41:20 00:07:43:20 TERRESTRIAL LIFE,
 HOWEVER,
 77 00:07:43:22 00:07:47:07 IS NOT AS DENSE
 AS IT IS IN THE OCEAN.
 78 00:07:47:09 00:07:49:19 AND BECAUSE OF
 CHEMICAL WEATHERING
 79 00:07:49:21 00:07:52:01 AND PREDATION,
 SCAVENGING, AND SO ON--
 80 00:07:52:03 00:07:53:18 BY OTHER ANIMALS--
 81 00:07:53:20 00:07:55:15 THE RECORD--
 ESPECIALLY VERTEBRATES--
 82 00:07:55:17 00:07:58:17 IS NOT
 REALLY AS COMPLETE
 AS WOULD BE DESIRABLE.
 83 00:07:58:19 00:08:00:09 *THEREFORE,*
THE RECORD OF LIFE
 84 00:08:00:11 00:08:02:28 *THAT DOES SURVIVE*
FROM THE GEOLOGIC PAST
 85 00:08:03:00 00:08:05:27 *IS SKEWED TOWARD*
MARINE ORGANISMS.
 86 00:08:05:29 00:08:09:03 *OF THESE, ORGANISMS*
WITH BONES OR SHELLS
 87 00:08:09:05 00:08:11:22 *ARE MOST LIKELY*
TO BE FOSSILIZED.
 88 00:08:11:24 00:08:13:08 *ONLY RARELY*
 89 00:08:13:10 00:08:16:05 *DO SOFTER BODY PARTS*
LEAVE FOSSIL IMPRESSIONS.
 90 00:08:16:07 00:08:19:00 *AND SO, ALMOST ALL*
ANCIENT ORGANISMS
 91 00:08:19:02 00:08:22:19 *LACKING HARD PARTS*
HAVE FADED INTO OBSCURITY.
 92 00:08:22:21 00:08:24:00 *THERE ARE, HOWEVER,*
 93 00:08:24:02 00:08:26:12 *A FEW SPECTACULAR*
EXCEPTIONS.

94 00:08:26:14 00:08:29:05 ONE OF THESE IS
STROMATOLITES.

95 00:08:29:07 00:08:31:13 THESE LUMPY ALGAL MATS

96 00:08:31:15 00:08:32:28 WERE THE DOMINANT
LIFE FORM

97 00:08:33:00 00:08:34:22 THROUGHOUT MUCH
OF EARTH'S HISTORY

98 00:08:34:24 00:08:37:22 BUT ARE NOW RESTRICTED
TO A FEW SMALL AREAS

99 00:08:37:24 00:08:39:26 OF WARM SHALLOW WATER.

100 00:08:39:28 00:08:41:05 STROMATOLITIC ALGAE

101 00:08:41:07 00:08:43:09 ADDED IMMENSE
AMOUNTS OF OXYGEN

102 00:08:43:11 00:08:45:00 TO EARTH'S
EARLY ATMOSPHERE

103 00:08:45:02 00:08:47:27 WITH IMPORTANT CONSEQUENCES
FOR THE EVOLUTION OF LIFE.

104 00:08:47:29 00:08:49:18 FOSSIL STROMATOLITES

105 00:08:49:20 00:08:51:12 APPEAR AS PILLAR
SHAPED LAYERS

106 00:08:51:14 00:08:53:19 OF SEDIMENTARY DEBRIS.

107 00:08:53:21 00:08:55:03 THE DEBRIS WAS TRAPPED

108 00:08:55:05 00:08:57:14 IN THE HAIR-LIKE
FILAMENTS OF THE ALGAE

109 00:08:57:16 00:08:59:15 WHEN IT WAS STILL ALIVE.

110 00:08:59:17 00:09:02:16 ALGAL TISSUE ITSELF
IS NOT PRESERVED.

111 00:09:02:18 00:09:05:09 PALEOBIOLOGIST
STANLEY AWRAMIK

112 00:09:05:11 00:09:06:25 SPECIALIZES IN THE STUDY

113 00:09:06:27 00:09:09:14 OF THESE ANCIENT
LIFE FORMS,

114 00:09:09:16 00:09:10:28 WHOSE FOSSILS DATE BACK

115 00:09:11:00 00:09:13:04 AS MUCH AS
3.5 BILLION YEARS.

116 00:09:13:06 00:09:15:19 THIS AREA
OF THE ALEXANDER HILLS

117 00:09:15:21 00:09:17:07 IN EASTERN CALIFORNIA

118 00:09:17:09 00:09:21:06 CONTAINS
AN INTERESTING SEQUENCE
OF STROMATOLITES.

119 00:09:21:08 00:09:23:22 HERE IN THE CRYSTAL
SPRING FORMATION,

120 00:09:23:24 00:09:26:17 WE HAVE A SEQUENCE
OF STROMATOLITES

121 00:09:26:19 00:09:28:13 WITH OTHER KINDS
OF SEDIMENTS

122 00:09:28:15 00:09:30:26 THAT ARE RECORDING
AN INTERESTING HISTORY

123 00:09:30:28 00:09:32:13 ON THE INTERPLAY

124 00:09:32:15 00:09:35:15 OF MICROORGANISMS
AND SEDIMENT.

125 00:09:36:22 00:09:38:28 THESE COLUMNAR
STROMATOLITES

126 00:09:39:00 00:09:42:12 REPRESENT THE TIME
WHEN THE MICROORGANISMS

127 00:09:42:14 00:09:45:05 WERE LIVING
IN SHALLOW WATER,
128 00:09:45:07 00:09:47:14 TRAPPING AND BINDING
THE SEDIMENT,
129 00:09:47:16 00:09:49:23 PRODUCING THE COLUMNAR
MORPHOLOGIES
130 00:09:49:25 00:09:52:27 THAT ARE
SO CHARACTERISTIC
OF STROMATOLITES.
131 00:09:52:29 00:09:56:04 THEN
ENVIRONMENTAL CONDITIONS
CHANGED SOMEWHAT,
132 00:09:56:06 00:10:00:08 WHERE COARSER SEDIMENT--
SANDS--CAME IN
133 00:10:00:10 00:10:03:13 AND STOPPED THE GROWTH
OF STROMATOLITE.
134 00:10:03:15 00:10:04:28 PROBABLY THE SEDIMENTS
135 00:10:05:00 00:10:06:16 WERE BEING DEPOSITED
TOO RAPIDLY,
136 00:10:06:18 00:10:09:08 AND THE CYANAL BACTERIA
JUST COULDN'T KEEP UP
137 00:10:09:10 00:10:11:23 WITH THIS RAPID RATE
OF SEDIMENTATION.
138 00:10:11:25 00:10:13:27 THEN CONDITIONS CHANGED
139 00:10:13:29 00:10:16:09 AND WENT BACK
TO QUIETER WATER--
140 00:10:16:11 00:10:18:26 AGAIN WITH PRECIPITATION
AND ACCUMULATION
141 00:10:18:28 00:10:20:20 OF CALCIUM CARBONATE--
142 00:10:20:22 00:10:22:28 AND THEN THE CONDITIONS
CONTINUED.
143 00:10:23:00 00:10:24:13 AND ABOVE HERE,
144 00:10:24:15 00:10:25:21 THE COLUMNAR
STROMATOLITES
145 00:10:25:23 00:10:27:12 AGAIN BEGIN
TO DEVELOP.
146 00:10:27:14 00:10:29:12 AND THEN HIGHER UP,
147 00:10:29:14 00:10:31:11 THESE COARSER SEDIMENTS
COME IN
148 00:10:31:13 00:10:33:15 AND STOP
STROMATOLITE GROWTH.
149 00:10:33:17 00:10:35:08 SO, IT'S BY STUDYING
150 00:10:35:10 00:10:37:07 THE INTERPLAY
OF THE MICROORGANISMS
151 00:10:37:09 00:10:38:22 WITH THE SEDIMENT
152 00:10:38:24 00:10:40:06 AND THE SEQUENCES
153 00:10:40:08 00:10:42:05 IN WHICH
THESE THINGS OCCUR
154 00:10:42:07 00:10:45:11 THAT A GEOLOGIST
CAN GET AN UNDERSTANDING
OF THE ENVIRONMENT
155 00:10:45:13 00:10:48:24 AND HEAR THE HISTORY
THAT WENT ON
156 00:10:48:26 00:10:50:25 WITH THE DEPOSITION
OF THESE ROCKS
157 00:10:50:27 00:10:53:03 IN THE CRYSTAL

158 00:10:54:11 00:10:55:28 THE CELL STRUCTURE
 OF STROMATOLITES
 159 00:10:56:00 00:10:58:28 AND ALL EARLY LIFE FORMS
 WAS VERY SIMPLE,
 160 00:10:59:00 00:11:02:03 A STRUCTURE BIOLOGISTS
 CALL PROKARYOTIC.
 161 00:11:03:27 00:11:05:18 PROKARYOTE CELLS
 DUPLICATE
 162 00:11:05:20 00:11:08:24 BY SPLITTING INTO EXACT
 REPLICAS OF THEMSELVES.
 163 00:11:11:00 00:11:12:20 LATER IN THE FOSSIL
 RECORD,
 164 00:11:12:22 00:11:16:00 MORE COMPLEX EUKARYOTE
 CELL STRUCTURE APPEARS.
 165 00:11:16:02 00:11:18:10 EUKARYOTES
 REPRODUCE SEXUALLY,
 166 00:11:18:12 00:11:19:25 RESULTING IN VARIATIONS
 167 00:11:19:27 00:11:21:16 IN NEWLY CREATED CELLS.
 168 00:11:23:11 00:11:26:15 MOST MODERN LIFE FORMS,
 INCLUDING ANIMALS,
 169 00:11:26:17 00:11:27:23 ARE EUKARYOTIC.
 170 00:11:29:00 00:11:31:19 PRIOR TO SEXUAL
 REPRODUCTION,
 171 00:11:31:21 00:11:36:10 ORGANISMS REPRODUCED
 BY DIVISION OF CELLS,
 172 00:11:36:12 00:11:39:08 AND IF YOU HAVE
 SIMPLE DIVISION--
 173 00:11:39:10 00:11:40:22 ASEXUAL REPRODUCTION--
 174 00:11:40:24 00:11:42:21 YOU'RE ESSENTIALLY
 HAVING THE PRODUCTION
 175 00:11:42:23 00:11:45:13 OF CLONES
 OF THE ORIGINAL ORGANISM
 176 00:11:45:15 00:11:48:04 CARRYING THE ORIGINAL
 ORGANISM'S DNA,
 177 00:11:48:06 00:11:50:17 AS LONG AS THERE IS
 NO MUTATION INVOLVED
 178 00:11:50:19 00:11:52:02 OR ANYTHING LIKE THAT.
 179 00:11:52:04 00:11:54:03 AND ESSENTIALLY THERE'S
 VERY LITTLE CHANCE,
 180 00:11:54:05 00:11:56:08 WITH THE EXCEPTION
 OF MUTATION,
 181 00:11:56:10 00:11:58:08 FOR EVOLUTION,
 BECAUSE YOU SIMPLY HAVE
 182 00:11:58:10 00:12:00:23 THE SAME ORGANISM
 BEING CLONED
 183 00:12:00:25 00:12:02:27 GENERATION
 AFTER GENERATION
 AFTER GENERATION.
 184 00:12:02:29 00:12:06:12 WHEN YOU FINALLY HAVE
 SEXUAL REPRODUCTION,
 185 00:12:06:14 00:12:08:13 YOU HAVE
 FOR THE FIRST TIME
 186 00:12:08:15 00:12:11:16 THE CHANCE FOR DNA
 TO COMBINE,
 187 00:12:11:18 00:12:14:07 TO HAVE

188 00:12:14:09 A BRAND-NEW ORGANISM
 00:12:17:05 THAT CONTAINS SOME
 189 00:12:17:07 00:12:20:00 OF EACH OF ITS PARENTS
 BUT IS ITSELF DIFFERENT
 190 00:12:20:02 00:12:23:02 FROM EITHER PARENT.
 AND SO YOU HAVE
 191 00:12:23:04 00:12:25:01 A WHOLE NEW ABILITY
 FOR THESE ORGANISMS
 192 00:12:27:13 00:12:29:29 TO CHANGE.
 ABOUT 600 MILLION
 193 00:12:30:01 00:12:33:05 YEARS AGO,
 MANY COMPLEX EUKARYOTE
 194 00:12:33:07 00:12:35:05 LIFE FORMS DEVELOPED
 WITH GEOLOGICAL
 195 00:12:35:07 00:12:37:13 SUDDENNESS.
 THOUGH SEXUAL REPRODUCTION
 196 00:12:37:15 00:12:39:15 NO DOUBT ACCELERATED
 THIS APPEARANCE
 197 00:12:39:17 00:12:42:14 OF NEW LIFE,
 NO ONE KNOWS EXACTLY
 198 00:12:42:16 00:12:44:21 WHY IT HAPPENED.
 THE FIRST APPEARANCE
 199 00:12:44:23 00:12:46:15 OF NUMEROUS FOSSILS
 IN ROCKS OF THIS AGE
 200 00:12:46:17 00:12:49:22 MARKS THE END OF
 THE LONG PRECAMBRIAN ERA
 201 00:12:49:24 00:12:52:29 AND THE BEGINNING
 OF THE PALEOZOIC ERA.
 202 00:12:53:01 00:12:56:08 THIS EVENT IS KNOWN
 AS THE CAMBRIAN EXPLOSION.
 203 00:12:56:10 00:12:58:07 THE PRESERVATION
 OF THESE FOSSILS
 204 00:12:58:09 00:12:59:22 WAS MADE POSSIBLE
 205 00:12:59:24 00:13:02:16 BY THE FACT THAT LIFE,
 FOR THE FIRST TIME,
 206 00:13:02:18 00:13:04:05 INCLUDED ABUNDANT
 HARD PARTS.
 207 00:13:04:07 00:13:07:02 THE SIGNIFICANCE OF
 THE CAMBRIAN EXPLOSION
 208 00:13:07:04 00:13:10:21 IS THAT THIS MARKS
 THE FIRST APPEARANCE--
 209 00:13:10:23 00:13:12:11 WIDESPREAD APPEARANCE--
 210 00:13:12:13 00:13:14:18 OF HARD-SHELLED
 ORGANISMS.
 211 00:13:14:20 00:13:17:20 UNDOUBTEDLY, SOME OF
 THE EARLIER ORGANISMS--
 212 00:13:17:22 00:13:19:14 PRECAMBRIAN--
 213 00:13:19:16 00:13:22:20 MUTATED AND EVOLVED
 HARD PARTS.
 214 00:13:22:22 00:13:25:04 BUT FOR SOME REASON
 THOSE HARD PARTS
 215 00:13:25:06 00:13:26:25 WERE AN ADVERSE THING,
 216 00:13:26:27 00:13:29:26 PROBABLY HAVING TO DO
 WITH THE AVAILABILITY
 OF OXYGEN.
 217 00:13:29:28 00:13:31:26 MOST OF THOSE

EARLIER CREATURES
218 00:13:31:28 00:13:34:06 ABSORBED OXYGEN THROUGH
THEIR SKIN TISSUES.
219 00:13:34:08 00:13:36:20 IF YOU CAN IMAGINE
A JELLYFISH
OR AN EARTHWORM,
220 00:13:36:22 00:13:38:15 IT HAS
LARGE SURFACE AREA
221 00:13:38:17 00:13:40:24 THROUGH WHICH IT
CAN ABSORB OXYGEN.
222 00:13:40:26 00:13:43:05 A HARD PART WOULD
INHIBIT THAT.
223 00:13:43:07 00:13:44:22 IN EARTH'S EARLY HISTORY
224 00:13:44:24 00:13:47:07 WE HAD MUCH LESS OXYGEN
IN THE ATMOSPHERE
225 00:13:47:09 00:13:48:24 THAN WE DO NOW.
226 00:13:48:26 00:13:52:06 BY THE CAMBRIAN, IT
MAY HAVE BEEN NECESSARY
227 00:13:52:08 00:13:55:05 FOR ANIMALS TO HAVE
HARD PARTS TO SURVIVE
228 00:13:55:07 00:13:57:20 BECAUSE OF OTHER
ANIMALS EATING THEM.
229 00:13:57:22 00:14:00:20 WITH A HARD SHELL,
YOU WERE LESS ATTRACTIVE
AND HARDER TO EAT,
230 00:14:00:22 00:14:02:22 SO YOU MIGHT
SURVIVE BETTER
231 00:14:02:24 00:14:05:10 THAN SOMETHING LIKE
AN EARTHWORM
OR A JELLYFISH.
232 00:14:05:12 00:14:07:14 THE CAMBRIAN PERIOD
MARKS THE BEGINNING
233 00:14:07:16 00:14:10:27 OF WHAT'S KNOWN AS THE
PALEOZOIC ERA OF GEOLOGIC TIME.
234 00:14:10:29 00:14:12:26 CONDITIONS ON EARTH
DURING THE PALEOZOIC
235 00:14:12:28 00:14:15:12 WERE IDEAL FOR
THE EVOLUTION OF LIFE.
236 00:14:15:14 00:14:17:12 WITHIN THE FIRST
50 MILLION YEARS,
237 00:14:17:14 00:14:20:22 ALL MAJOR GROUPS OF ORGANISMS
WHICH STILL SURVIVE TODAY
238 00:14:20:24 00:14:23:17 HAD EVOLVED, INCLUDING
THE FIRST VERTEBRATES,
239 00:14:23:19 00:14:25:16 OUR MOST ANCIENT ANCESTORS.
240 00:14:25:18 00:14:27:03 DURING THE PALEOZOIC,
241 00:14:27:05 00:14:29:16 CONTINENTS WERE DRIFTING
TOWARD THE EQUATOR
242 00:14:29:18 00:14:32:00 TRANSFORMING COLD,
GLACIATED TERRAIN
243 00:14:32:02 00:14:34:04 INTO WARM, SHALLOW SEAS.
244 00:14:34:06 00:14:36:06 ORGANISMS THRIVED
AND DIVERSIFIED
245 00:14:36:08 00:14:37:22 IN THIS ENVIRONMENT.
246 00:14:37:24 00:14:39:21 THE BOTTOMS
OF THESE SHALLOW SEAS

247 00:14:39:23 00:14:42:13 WERE LITERALLY CARPETED
 WITH INVERTEBRATE ANIMALS,
 248 00:14:42:15 00:14:44:21 INCLUDING BRACHIOPODS,
 TRILOBITES,
 249 00:14:44:23 00:14:46:12 AND PRIMITIVE CORALS.
 250 00:14:46:14 00:14:49:10 ABOVE THESE SWAM
 THE FIRST FISHES.
 251 00:14:49:12 00:14:51:04 BY MIDDLE PALEOZOIC TIME,
 252 00:14:51:06 00:14:54:05 PLANTS AND ANIMALS HAD MADE
 THEIR WAY OUT OF THE OCEANS
 253 00:14:54:07 00:14:56:06 AND BEGAN
 TO POPULATE THE LAND.
 254 00:14:56:08 00:14:59:05 *THE FIRST APPEARANCE OF LIFE*
OUT OF THE SEAS
 255 00:14:59:07 00:15:00:26 *WAS POSSIBLE*
IN LARGE PART
 256 00:15:00:28 00:15:02:18 *BECAUSE THE PLANET'S*
ATMOSPHERE
 257 00:15:02:20 00:15:04:19 *HAD BECOME OXYGEN RICH*
 258 00:15:04:21 00:15:08:06 *DUE TO PHOTOSYNTHESIS*
OF STROMATOLITIC ALGAE.
 259 00:15:08:08 00:15:09:25 *AS OXYGEN BUILT UP,*
 260 00:15:09:27 00:15:12:28 *AN OZONE LAYER FORMED*
HIGH IN THE ATMOSPHERE
 261 00:15:13:00 00:15:14:19 *SHIELDING*
THE EARTH'S SURFACE
 262 00:15:14:21 00:15:17:09 *FROM DEADLY*
SOLAR RADIATION.
 263 00:15:17:11 00:15:18:24 *ALTHOUGH THIS PROCESS*
 264 00:15:18:26 00:15:21:09 *WAS ACTUALLY WELL UNDER WAY*
IN THE PRECAMBRIAN,
 265 00:15:21:11 00:15:23:29 *IT WAS NOT UNTIL*
THE MID-PALEOZOIC
 266 00:15:24:01 00:15:25:25 *THAT LIFE WAS*
SUFFICIENTLY DEVELOPED
 267 00:15:25:27 00:15:28:11 *TO TAKE ADVANTAGE*
OF THE DRY LAND HABITATS
 268 00:15:28:13 00:15:30:13 *THE OZONE LAYER*
PROTECTED.
 269 00:15:30:15 00:15:33:19 *AT THE SAME TIME OXYGEN*
INCREASED IN THE ATMOSPHERE,
 270 00:15:33:21 00:15:37:18 *ANOTHER ATMOSPHERIC GAS--*
CARBON DIOXIDE--DECREASED,
 271 00:15:37:20 00:15:39:07 *BECAUSE CARBON DIOXIDE*
 272 00:15:39:09 00:15:42:05 *HAD BECOME AN IMPORTANT*
BUILDING BLOCK OF LIFE.
 273 00:15:42:07 00:15:44:05 *A LOT*
OF THE CARBON DIOXIDE
 274 00:15:44:07 00:15:46:19 *IS TRAPPED IN ORGANISMS,*
IN SEA WATER,
 275 00:15:46:21 00:15:49:26 *AND EVENTUALLY*
BECOMES LIME OOZES
ON THE SEA FLOOR
 276 00:15:49:28 00:15:53:01 *WHICH MAY EVENTUALLY*
BECOME LIMESTONE.
 277 00:15:53:03 00:15:56:00 *SO ORGANISMS ARE*

278 00:15:56:02 00:15:58:23 VERY MUCH A PART OF THE CONTROL
 OF OUR ENVIRONMENT.
 279 00:15:58:25 00:16:01:22 THE PLANTS TAKE IN
 THE CARBON DIOXIDE
 280 00:16:01:24 00:16:03:04 AND GIVE OFF OXYGEN.
 281 00:16:03:06 00:16:04:19 SO THE PLANTS...
 282 00:16:04:21 00:16:06:19 THE LIMESTONES...
 283 00:16:06:21 00:16:07:20 THE OCEAN...
 284 00:16:07:22 00:16:09:03 THE ATMOSPHERE...
 285 00:16:09:05 00:16:10:07 HUMAN BEINGS...
 286 00:16:10:09 00:16:11:15 HORSES AND CAMELS...
 287 00:16:11:17 00:16:13:01 THE SYCAMORE TREE
 OUTSIDE
 288 00:16:13:03 00:16:15:28 ARE ALL INTERRELATED
 IN A BIG CYCLE
 289 00:16:16:00 00:16:17:27 CALLED THE CARBON CYCLE.
 290 00:16:17:29 00:16:19:10 THE LATE PALEOZOIC
 291 00:16:19:12 00:16:22:12 WAS A TIME OF GREAT
 GLOBAL-SCALE CHANGES.
 292 00:16:22:14 00:16:24:27 DURING THIS TIME
 ALMOST ALL
 OF THE CONTINENTS
 293 00:16:24:29 00:16:27:28 WERE TECTONICALLY
 ASSEMBLED INTO A SINGLE
 SUPERCONTINENT
 294 00:16:28:00 00:16:29:15 CALLED PANGAEA.
 295 00:16:29:17 00:16:32:07 THIS IMMENSE LAND MASS
 NEARLY SPANNED THE EARTH
 296 00:16:32:09 00:16:34:08 FROM POLE TO POLE,
 297 00:16:34:10 00:16:35:22 FORMING A TREMENDOUS
 NORTH/SOUTH BARRIER
 298 00:16:35:24 00:16:38:05 THAT BLOCKED
 OCEAN CIRCULATION
 299 00:16:38:07 00:16:40:20 AND SEVERELY DISRUPTED
 THE CLIMATE.
 300 00:16:40:22 00:16:43:08 THE CONTINENTAL
 COLLISIONS THAT
 CREATED PANGAEA
 301 00:16:43:10 00:16:45:15 ALSO TRANSFORMED
 CONTINENTAL MARGINS
 302 00:16:45:17 00:16:47:22 FROM SHALLOW SEAS
 WITH LIFE
 303 00:16:47:24 00:16:49:01 INTO MOUNTAIN RANGES
 304 00:16:49:03 00:16:51:21 SIMILAR TO THE ALPS
 AND THE HIMALAYAS.
 305 00:16:51:23 00:16:55:12 THESE CHANGES
 IN CLIMATE AND TERRAIN
 IN LATE PALEOZOIC TIME
 306 00:16:55:14 00:16:57:29 HAD A GRAVE EFFECT
 ON THE GLOBAL ECOSYSTEM
 307 00:16:58:01 00:16:59:28 AND TRIGGERED
 THE LARGEST
 MASS EXTINCTION
 308 00:17:00:00 00:17:01:22 IN ALL
 OF EARTH HISTORY.

309 00:17:01:24 00:17:04:12 IN THIS TRAGIC FINALE
TO A GEOLOGIC ERA,
310 00:17:04:14 00:17:08:27 OVER 90% OF ALL KNOWN
SPECIES OF LIFE
DISAPPEARED.
311 00:17:08:29 00:17:11:01 *THE SMALL PERCENTAGE
OF SPECIES*
312 00:17:11:03 00:17:13:00 *THAT SURVIVED
THE MASS EXTINCTION*
313 00:17:13:02 00:17:15:00 *AT THE END
OF THE PALEOZOIC*
314 00:17:15:02 00:17:16:29 *INHABITED A WORLD
OF OPPORTUNITIES,*
315 00:17:17:01 00:17:21:00 *MOVING INTO ENVIRONMENTS
NOW FREE OF COMPETITORS.*
316 00:17:21:02 00:17:24:29 *THE FOSSIL RECORD SUGGESTS
THAT INDIVIDUAL SPECIES*
317 00:17:25:01 00:17:28:01 *GAVE RISE TO A MULTITUDE
OF NEW LIFE FORMS,*
318 00:17:28:03 00:17:31:15 *EACH WELL-SUITED TO ITS
PARTICULAR ENVIRONMENT.*
319 00:17:33:02 00:17:35:29 MASS EXTINCTIONS
HAVE OCCURRED
320 00:17:36:01 00:17:38:00 THROUGHOUT
THE HISTORY OF LIFE.
321 00:17:38:02 00:17:40:15 THE IMPACT OF THESE
MASS EXTINCTIONS
322 00:17:40:17 00:17:43:01 IN SOME WAYS
COULD BE VIEWED
323 00:17:43:03 00:17:46:01 AS TAKING OUT
A LOT OF ORGANISMS
324 00:17:46:03 00:17:49:00 AND ALLOWING
FOR NEWER ORGANISMS
TO EVOLVE
325 00:17:49:02 00:17:52:00 AND REPOPULATE
THE EARTH
326 00:17:52:02 00:17:53:16 WITH DIFFERENT
SPECIES.
327 00:17:53:18 00:17:55:17 *THE ARRIVAL
OF NEW SPECIES*
328 00:17:55:19 00:17:59:12 *IN THE AFTERMATH OF THE
PALEOZOIC MASS EXTINCTION*
329 00:17:59:14 00:18:02:14 *HERALDS THE NEXT
GEOLOGIC ERA--*
330 00:18:02:16 00:18:04:00 *THE MESOZOIC.*
331 00:18:05:27 00:18:07:13 EVOLUTION IN THE MESOZOIC
332 00:18:07:15 00:18:09:28 WAS CRITICAL
FOR LIFE ON EARTH.
333 00:18:10:00 00:18:11:28 AT THIS TIME,
LIFE WAS TRANSFORMED
334 00:18:12:00 00:18:13:28 FROM ANCIENT
TO MORE MODERN FORMS.
335 00:18:14:00 00:18:16:28 REEF-BUILDING CORALS APPEARED
ON CONTINENTAL MARGINS,
336 00:18:17:00 00:18:19:13 AND LARGE REPTILES
JOINED THE FISHES

337 00:18:19:15 00:18:21:07 AS SWIMMING PREDATORS.
 338 00:18:21:09 00:18:22:23 LATER IN THE MESOZOIC,
 339 00:18:22:25 00:18:24:28 THE FLOWERING PLANTS
 AND DECIDUOUS TREES
 340 00:18:25:00 00:18:26:12 FIRST EVOLVED ON LAND,
 341 00:18:26:14 00:18:29:28 AS WELL AS FLYING REPTILES
 AND THE FIRST BIRDS.
 342 00:18:30:00 00:18:31:13 MAMMALS
 WERE ALSO PRESENT,
 343 00:18:31:15 00:18:34:09 BUT THEY WERE SMALL
 AND INCONSPICUOUS.
 344 00:18:34:11 00:18:36:10 DESPITE THIS
 PROLIFERATION OF LIFE,
 345 00:18:36:12 00:18:38:25 THE MESOZOIC ERA
 IS BEST KNOWN
 346 00:18:38:27 00:18:40:28 AS THE AGE
 OF THE DINOSAURS.
 347 00:18:41:00 00:18:43:13 IT WAS THESE SO-CALLED
 TERRIBLE LIZARDS
 348 00:18:43:15 00:18:46:19 THAT DOMINATED THE LAND
 FOR SOME 140 MILLION YEARS.
 349 00:18:46:21 00:18:48:20 *DINOSAURS CAPTURED*
THE PUBLIC'S IMAGINATION
 350 00:18:48:22 00:18:51:11 *FROM THE TIME THEIR FOSSILS*
WERE FIRST EXCAVATED
 351 00:18:51:13 00:18:53:27 *IN THE EARLY*
19th CENTURY.
 352 00:18:53:29 00:18:56:26 *SOON THE RUSH BEGAN*
TO COLLECT THE REMNANTS
 353 00:18:56:28 00:18:59:05 *OF THESE ANCIENT*
CREATURES.
 354 00:18:59:07 00:19:01:26 *EXPEDITIONS*
SPANNED THE GLOBE
 355 00:19:01:28 00:19:03:26 *UNCOVERING EVERYTHING*
FROM DINOSAUR SKULLS
 356 00:19:03:28 00:19:06:11 *TO FOSSILIZED*
DINOSAUR EGGS.
 357 00:19:06:13 00:19:08:11 *PIECE BY PIECE,*
 358 00:19:08:13 00:19:11:12 *A SPECTACULAR VIEW*
OF EARTH'S PAST INHABITANTS
 359 00:19:11:14 00:19:13:27 *GRADUALLY TOOK SHAPE.*
 360 00:19:13:29 00:19:15:26 *DINOSAURS WERE SEEN*
AS SOLITARY,
 361 00:19:15:28 00:19:17:26 *COLD-BLOODED CREATURES*
 362 00:19:17:28 00:19:20:11 *WHO MOVED THROUGH*
THEIR TROPICAL WORLD
 363 00:19:20:13 00:19:21:25 *AT A SLUGGISH PACE.*
 364 00:19:22:27 00:19:24:11 *BUT RECENT DATA,*
 365 00:19:24:13 00:19:26:12 *TOGETHER WITH*
A BETTER UNDERSTANDING
 366 00:19:26:14 00:19:27:28 *OF BIOLOGY,*
 367 00:19:28:00 00:19:30:27 *HAVE PROMPTED SCIENTISTS*
TO RETHINK THIS VIEW.
 368 00:19:30:29 00:19:34:26 *FOSSIL TRACKS INDICATE*
MANY OF THESE CREATURES
 369 00:19:34:28 00:19:37:03 *MUST HAVE BEEN*

370 00:19:37:05 00:19:39:18 *DINOSAUR FOSSILS HAVE ALSO
BEEN DISCOVERED*
 371 00:19:39:20 00:19:42:06 *IN PLACES THAT WERE DRY
AND HAD COOL CLIMATES*
 372 00:19:42:08 00:19:43:27 *DURING THE MESOZOIC.*
 373 00:19:43:29 00:19:45:16 *THIS AND OTHER EVIDENCE*
 374 00:19:45:18 00:19:48:03 *SUGGESTS THESE ANIMALS
WERE WARM-BLOODED.*
 375 00:19:48:05 00:19:49:25 *PREDATORY DINOSAURS*
 376 00:19:49:27 00:19:52:24 *APPARENTLY REQUIRED
LARGE AMOUNTS OF FOOD*
 377 00:19:52:26 00:19:54:08 *FOR SURVIVAL,*
 378 00:19:54:10 00:19:56:09 *SUGGESTING THE HIGH RATE
OF METABOLISM*
 379 00:19:56:11 00:19:58:09 *TYPICAL*
 380 00:19:58:11 00:20:01:24 *OF WARM-BLOODED ANIMALS.*
 381 00:20:01:26 00:20:04:25 *FINALLY, FAR FROM LIVING
SOLITARY LIVES,*
 382 00:20:04:27 00:20:06:21 *SOME DINOSAURS LIVED*
 383 00:20:06:23 00:20:10:09 *IN NEST-BUILDING HERDS,*
 384 00:20:10:11 00:20:12:09 *CARING FOR THEIR YOUNG.*
 385 00:20:12:11 00:20:14:09 *THE DINOSAURS MIGHT STILL*
 386 00:20:14:11 00:20:16:24 *DOMINATE OUR WORLD TODAY,*
 387 00:20:16:26 00:20:18:25 *EVEN MORE DIVERSE*
 388 00:20:18:27 00:20:21:10 *AND SPECTACULAR*
 389 00:20:21:12 00:20:23:27 *THAN EVER BEFORE,*
 390 00:20:23:29 00:20:27:15 *BUT FOR ANOTHER DRASTIC*
 391 00:20:27:17 00:20:30:09 *ENVIRONMENTAL CHANGE*
 392 00:20:30:11 00:20:33:25 *65 MILLION YEARS AGO,*
 393 00:20:33:27 00:20:36:10 *WHICH TRIGGERED*
 394 00:20:36:12 00:20:38:10 *YET ANOTHER ROUND*
 395 00:20:38:12 00:20:40:28 *OF WORLD-WIDE*
 396 00:20:41:00 00:20:44:24 *MASS EXTINCTIONS.*
 397 00:20:44:26 00:20:46:24 *GEOLOGIC CLUES SUGGEST*
 398 00:20:46:26 00:20:49:22 *SEVERAL NATURAL PHENOMENA*
 399 00:20:49:24 00:20:51:06 *MAY HAVE BEEN RESPONSIBLE*
 400 00:20:51:08 00:20:54:08 *FOR THE CHANGE.*
 401 00:20:54:10 00:20:56:24 *DUST FROM EXTREMELY INTENSE*
 402 00:20:56:26 00:20:59:23 *VOLCANIC ERUPTIONS*
 POSSIBLY COOLED
 THE ATMOSPHERE ENOUGH
 TO CHANGE EARTH'S CLIMATE
 AND SERIOUSLY DISRUPT
 THE FOOD CHAIN.
 OR A LARGE ASTEROID
 MAY HAVE STRUCK THE EARTH,
 COOLING IT,
 AS SMOKE AND DUST
 BLOCKED OUT SUNLIGHT.
 WHATEVER THE CAUSE,
 MANY SPECIES
 WERE NO LONGER WELL-SUITED
 FOR THEIR ENVIRONMENTS.
 THE MASS EXTINCTION
 AT THE END OF THE MESOZOIC

403 00:20:59:25 00:21:01:22 NOT ONLY EXTERMINATED
 THE DINOSAURS,
 404 00:21:01:24 00:21:04:07 IT USHERED IN THE PRESENT
 ERA OF GEOLOGIC TIME--
 405 00:21:04:09 00:21:05:22 THE CENOZOIC.
 406 00:21:05:24 00:21:08:22 CENOZOIC TIME IS MARKED BY
 INTENSE TECTONIC CHANGES
 407 00:21:08:24 00:21:11:23 WHICH HELPED TO DIRECT EVENTS
 IN EVOLUTION.
 408 00:21:11:25 00:21:14:22 FOR EXAMPLE, WHEN AUSTRALIA
 BECAME TECTONICALLY DETACHED
 409 00:21:14:24 00:21:16:07 FROM OTHER CONTINENTS,
 410 00:21:16:09 00:21:18:21 MAMMALS RIDING ABOARD
 THIS DRIFTING LAND MASS
 411 00:21:18:23 00:21:21:07 PROCEEDED ON THEIR OWN
 EVOLUTIONARY PATH,
 412 00:21:21:09 00:21:23:07 RESULTING
 IN THE UNUSUAL FORMS
 413 00:21:23:09 00:21:25:07 WE SEE
 IN AUSTRALIA TODAY,
 414 00:21:25:09 00:21:27:23 SUCH AS
 THE DUCKBILLED PLATYPUS,
 415 00:21:27:25 00:21:30:16 THE SPINY ANTEATER,
 AND THE KANGAROO.
 416 00:21:30:18 00:21:33:07 THE ECOLOGICAL CRISIS
 OF THE MESOZOIC EXTINCTION
 417 00:21:33:09 00:21:35:22 AND THE TECTONIC ACTIVITY
 WHICH FOLLOWED
 418 00:21:35:24 00:21:38:22 HELPED SET THE STAGE
 FOR EVENTS IN EVOLUTION
 419 00:21:38:24 00:21:40:22 WHICH ULTIMATELY
 ALLOWED MAMMALS
 420 00:21:40:24 00:21:42:13 TO DOMINATE THE LAND.
 421 00:21:42:15 00:21:45:07 AN EXTRAORDINARY RECORD
 OF LIFE IN THE CENOZOIC
 422 00:21:45:09 00:21:48:07 HAS BEEN FOUND IN A RATHER
 UNEXPECTED PLACE--
 423 00:21:48:09 00:21:49:21 BURIED BENEATH THE STREETS
 424 00:21:49:23 00:21:52:05 OF ONE OF THE WORLD'S
 LARGEST CITIES.
 425 00:21:55:07 00:21:58:05 AT RANCHO LA BREA
 IN LOS ANGELES,
 426 00:21:58:07 00:22:02:06 NATURAL TAR POOLS HAVE TRAPPED
 THOUSANDS OF ANIMALS.
 427 00:22:02:08 00:22:05:21 THE TAR HAS PRESERVED
 AN ESPECIALLY COMPLETE RECORD
 428 00:22:05:23 00:22:08:20 OF PREHISTORIC LIFE
 FROM THE LATE CENOZOIC ERA.
 429 00:22:08:22 00:22:11:20 THE LAST FEW MILLION YEARS
 OF EARTH HISTORY--
 430 00:22:11:22 00:22:14:21 IN FACT, THE LAST
 TWO MILLION YEARS
 431 00:22:14:23 00:22:17:20 HAS GENERALLY
 BEEN CONSIDERED
 THE ICE AGES.
 432 00:22:17:22 00:22:22:06 IT IS THAT SETTING

THAT, UH, GOVERNS
 WHAT WE SEE
 433 00:22:22:08 00:22:24:06 HERE AT
 RANCHO LA BREA.
 434 00:22:24:08 00:22:28:06 WE ARE IN THE LAST HALF
 OF THE LAST GLACIAL PERIOD,
 435 00:22:28:08 00:22:31:10 JUST BEFORE
 MODERN CLIMATES
 COME ABOUT.
 436 00:22:31:12 00:22:35:16 THE OLDEST REMAINS HERE
 AT RANCHO LA BREA
 OF VERTEBRATES--
 437 00:22:35:18 00:22:37:06 TERRESTRIAL
 VERTEBRATES--
 438 00:22:37:08 00:22:40:08 UH, ARE ABOUT 36,000,
 38,000 YEARS OLD.
 439 00:22:40:10 00:22:43:05 AND THE FOSSIL RECORD HERE
 EXTENDS FROM THAT PERIOD
 440 00:22:43:07 00:22:46:07 UP TO ABOUT
 10,000 YEARS AGO.
 441 00:22:47:19 00:22:50:11 *THE LA BREA TAR PITS*
HAVE YIELDED FOSSILS
 442 00:22:50:13 00:22:52:18 *RANGING*
FROM MICROSCOPIC PLANTS
 443 00:22:52:20 00:22:54:03 *AND POLLEN SPORES*
 444 00:22:54:05 00:22:57:19 *TO GIANT MAMMOTHS*
AND BISONS.
 445 00:22:57:21 00:23:00:18 FOR ME, THE MOST FUN
 IS NOT SO MUCH
 FINDING THE FOSSIL,
 446 00:23:00:20 00:23:02:10 IT'S IDENTIFYING IT.
 447 00:23:02:12 00:23:05:03 SUDDENLY THIS JUST
 ISN'T A LUMP OF BONES.
 448 00:23:05:05 00:23:08:17 SUDDENLY IT'S
 A SABER-TOOTH CAT SKULL,
 A BISON FEMUR.
 449 00:23:08:19 00:23:10:17 THERE'S A THRILL
 WHEN YOU REALIZE
 450 00:23:10:19 00:23:12:06 THIS ISN'T
 JUST A FOSSIL.
 451 00:23:12:08 00:23:16:04 THIS IS A PARTICULAR
 KIND OF ANIMAL
 THAT DIED HERE.
 452 00:23:16:06 00:23:17:20 THAT'S EXCITING
 FOR ME.
 453 00:23:17:22 00:23:19:20 *AS THE SITE*
IS EXCAVATED,
 454 00:23:19:22 00:23:21:19 *THE POSITIONS*
OF EVERY FOSSIL
 455 00:23:21:21 00:23:23:19 *ARE CAREFULLY MEASURED*
AND CATALOGED.
 456 00:23:23:21 00:23:26:05 AT THE END
 OF THE EXCAVATION,
 457 00:23:26:07 00:23:28:19 WE WANT TO BE ABLE
 TO RECONSTRUCT
 458 00:23:28:21 00:23:31:19 EXACTLY HOW THESE BONES

459 00:23:31:21 CAME TO BE DEPOSITED.
 00:23:34:18 WHAT HAPPENED TO
 THIS ANIMAL BETWEEN
 DYING IN THE ASPHALT
 460 00:23:34:20 00:23:36:09 AND DIGGING IT UP?
 461 00:23:36:11 00:23:39:03 WHEN WE TAKE MEASUREMENTS
 ON EACH BONE,
 462 00:23:39:05 00:23:42:17 WE HOPE TO RECONSTRUCT
 HOW THIS BONE HAS MOVED
 THROUGH TIME
 463 00:23:42:19 00:23:44:05 IN THE DEPOSIT
 464 00:23:44:07 00:23:47:04 AND PUT IT BACK
 WITH THE REST
 OF THE ANIMAL
 465 00:23:47:06 00:23:50:03 TO DETERMINE WHAT HAPPENS
 TO THESE INDIVIDUALS
 WHEN THEY DECOMPOSE
 466 00:23:50:05 00:23:52:18 AND AS THE PIT
 IS DEPOSITED
 THROUGH TIME.
 467 00:23:52:20 00:23:54:03 *AFTER EXCAVATION,*
 468 00:23:54:05 00:23:56:23 *THE BONES ARE TAKEN*
TO THE NEARBY LAB
 469 00:23:56:25 00:23:58:06 *FOR ANALYSIS.*
 470 00:23:58:08 00:24:00:13 *EXAMINING THE MATERIAL*
AROUND THE BONES
 471 00:24:00:15 00:24:04:18 *IS AS IMPORTANT AS IDENTIFYING*
THE BONES THEMSELVES.
 472 00:24:04:20 00:24:08:00 ALL OF THE SOIL
 SURROUNDING THAT LARGER BONE
 473 00:24:08:02 00:24:10:02 WHEN IT'S CLEANED OFF,
 474 00:24:10:04 00:24:12:18 UM, WILL BE GONE THROUGH
 475 00:24:12:20 00:24:14:16 UNDERNEATH
 THE MAGNIFYING GLASS,
 476 00:24:14:18 00:24:17:04 LOOKING FOR THE SMALL
 BONES AND PLANTS
 477 00:24:17:06 00:24:20:04 AND SHELLS
 AND INSECT MATERIAL.
 478 00:24:20:06 00:24:27:03 UM, MICROFOSSILS
 ARE THAT TOOL THAT YOU NEED
 479 00:24:27:05 00:24:29:18 TO REALLY RECONSTRUCT
 AN ENVIRONMENT.
 480 00:24:29:20 00:24:32:02 UM, THEY GIVE YOU
 MUCH MORE INFORMATION
 481 00:24:32:04 00:24:35:03 ABOUT RAINFALL
 AND--AND CLIMATE CHANGES
 482 00:24:35:05 00:24:38:03 THAN LARGE BONES DO.
 483 00:24:38:05 00:24:41:17 UM, LARGE ANIMALS DIDN'T
 NECESSARILY LIVE HERE.
 484 00:24:41:19 00:24:43:18 THEY JUST DIED HERE,
 485 00:24:43:20 00:24:47:03 WHEREAS A MOUSE
 OR--OR A GOPHER
 486 00:24:47:05 00:24:49:15 PROBABLY SPENT
 ITS ENTIRE LIFE
 487 00:24:49:17 00:24:52:02 RIGHT WITHIN THE AREA
 OF THE PARK,

488 00:24:52:04 00:24:56:01 SO IT IS VERY IMPORTANT
THAT WE DO COLLECT

489 00:24:56:03 00:24:59:09 ALL OF THESE SMALL THINGS.
490 00:24:59:11 00:25:02:16 THROUGH CAREFUL IDENTIFICATION
OF FOSSILS

491 00:25:02:18 00:25:04:01 COLLECTED
AT THE TAR PITS,
492 00:25:04:03 00:25:07:00 SCIENTISTS HAVE BEEN ABLE
TO RECONSTRUCT
493 00:25:07:02 00:25:10:17 THE FORMER HABITAT
AT RANCHO LA BREA.

494 00:25:10:19 00:25:12:02 40,000 YEARS AGO,
495 00:25:12:04 00:25:15:01 THE LOS ANGELES BASIN
WAS A SAGEBRUSH PLAIN
496 00:25:15:03 00:25:18:01 DOTTED WITH GROVES
OF CYPRESS AND PINE
497 00:25:18:03 00:25:19:22 AND STREAMSIDE WOODLANDS.
498 00:25:21:06 00:25:24:02 A GREAT ABUNDANCE
AND DIVERSITY OF ANIMALS
499 00:25:24:04 00:25:26:17 LIVED HERE,
INCLUDING DEER,
500 00:25:26:19 00:25:28:25 DIRE WOLVES,
SABER-TOOTH CATS,
501 00:25:28:27 00:25:31:16 GROUND SLOTHS,
AND MASTODONS.
502 00:25:33:03 00:25:36:00 MOST OF THE LARGER MAMMALS
IN THIS ECOSYSTEM
503 00:25:36:02 00:25:37:20 HAVE SINCE BECOME EXTINCT.
504 00:25:41:07 00:25:43:17 THE FOSSILS
AT RANCHO LA BREA
505 00:25:43:19 00:25:46:16 REPRESENT A VERY BRIEF SPAN
OF LATE CENOZOIC TIME--
506 00:25:46:18 00:25:49:01 JUST 25,000
TO 30,000 YEARS.
507 00:25:49:03 00:25:51:14 THOUGH FEW
ANCIENT LIFE LOCALITIES
508 00:25:51:16 00:25:53:28 ARE AS RICH
AS RANCHO LA BREA,
509 00:25:54:00 00:25:56:29 OTHER CENOZOIC FOSSILS
PROVIDE SPECTACULAR EVIDENCE
510 00:25:57:01 00:25:59:28 OF EVOLUTION
SPANNING MILLIONS OF YEARS.
511 00:26:00:02 00:26:02:29 THE CASE OF THE HORSE
IS ESPECIALLY STUNNING.
512 00:26:03:01 00:26:05:29 APPEARING NEAR THE BEGINNING
OF THE CENOZOIC,
513 00:26:06:01 00:26:08:29 THE FIRST HORSES
WERE NO LARGER THAN DOGS
514 00:26:09:01 00:26:11:29 AND HAD FOUR TOES
ON EACH FOOT.
515 00:26:12:01 00:26:13:14 THEY LIVED
IN WOODLANDS.
516 00:26:13:16 00:26:16:15 THEN ABOUT 40 MILLION
YEARS AGO,
517 00:26:16:17 00:26:19:00 A NEW ECOSYSTEM
APPEARED ON EARTH--

518 00:26:19:02 00:26:20:15 *THE GRASSLANDS.*
 519 00:26:20:17 00:26:23:13 *MOVING IN*
 TO FORAGE THIS ENVIRONMENT,
 520 00:26:23:15 00:26:24:29 *THE HORSE GREW LARGER,*
 521 00:26:25:01 00:26:27:08 *AND THROUGH TIME,*
 DEVELOPED HOOVES
 522 00:26:27:10 00:26:29:21 *TO REPLACE TOES.*
 523 00:26:32:17 00:26:34:29 *THIS PERMITTED HORSES*
 TO RUN SWIFTLY
 524 00:26:35:01 00:26:37:14 *WITH BETTER CHANCE*
 OF SURVIVAL IN THE OPEN.
 525 00:26:37:16 00:26:39:28 *THE IDEA THAT SPECIES*
 GRADUALLY CHANGED
 526 00:26:40:00 00:26:42:20 *TO BETTER SUIT*
 THEIR NATURAL HABITATS
 527 00:26:42:22 00:26:45:05 *WAS FIRST DESCRIBED*
 BY CHARLES DARWIN
 528 00:26:45:07 00:26:47:14 *SOME 150 YEARS AGO.*
 529 00:26:47:16 00:26:50:09 *THE MAIN THING*
 THAT DARWIN CONTRIBUTED
 530 00:26:50:11 00:26:53:13 *TO OUR IDEA*
 OF LIFE IN THE PAST
 531 00:26:53:15 00:26:54:28 *AND WHAT HAPPENED*
 532 00:26:55:00 00:26:57:27 *WAS THE METHOD*
 OF EVOLUTION.
 533 00:26:57:29 00:27:03:12 *UM, PRIOR TO DARWIN'S,*
 UH, IDEA OF EVOLUTION,
 534 00:27:03:14 00:27:06:26 *UM, WE KNEW THAT PLANTS*
 AND ANIMALS CHANGED.
 535 00:27:06:28 00:27:09:26 *UH, WE KNEW THAT*
 THEY VARIED OVER TIME,
 536 00:27:09:28 00:27:12:13 *BUT WE DIDN'T REALLY*
 HAVE AN IDEA
 537 00:27:12:15 00:27:14:12 *AS TO WHY THEY CHANGED,*
 538 00:27:14:14 00:27:16:22 *AND DARWIN*
 GAVE US THE METHOD.
 539 00:27:16:24 00:27:20:12 *DARWIN OBSERVED THAT WITHIN*
 EVERY POPULATION OF ANIMALS,
 540 00:27:20:14 00:27:22:27 *THERE IS A RANGE*
 OF CHARACTERISTICS,
 541 00:27:22:29 00:27:27:01 *BE IT DIFFERENT HEIGHTS,*
 AGILITY, OR HAIR COLOR.
 542 00:27:27:03 00:27:30:12 *THOSE ANIMALS WHOSE FEATURES*
 MOST EXPOSE THEM TO DANGER
 543 00:27:30:14 00:27:33:12 *TEND TO DIE OUT,*
 LEAVING FEW OFFSPRING.
 544 00:27:33:14 00:27:34:27 *THOSE ANIMALS*
 545 00:27:34:29 00:27:36:27 *WITH MORE FAVORABLE*
 FEATURES SURVIVE,
 546 00:27:36:29 00:27:38:15 *AND THROUGH REPRODUCTION,*
 547 00:27:38:17 00:27:41:20 *PASS ON THESE CHARACTERISTICS*
 TO FUTURE GENERATIONS.
 548 00:27:43:01 00:27:45:13 *BUT FEATURES FAVORABLE*
 AT ONE TIME
 549 00:27:45:15 00:27:47:04 *WON'T BE FAVORABLE*
 DURING ANOTHER,

550 00:27:47:06 00:27:49:17 *AND SO ANIMALS EVOLVE.*
551 00:27:49:19 00:27:53:09 *YET DARWIN'S MODEL*
HAS RUN INTO SOME DIFFICULTY.
552 00:27:55:26 00:27:58:25 *DARWIN WAS A GRADUALIST,*
553 00:27:58:27 00:28:01:24 *AND THAT IS*
HE THOUGHT THAT EVOLUTION
554 00:28:01:26 00:28:04:11 *PROCEEDED VERY SLOWLY,*
555 00:28:04:13 00:28:07:10 *AND BECAUSE OF THAT,*
HIS THEORY OF EVOLUTION
556 00:28:07:12 00:28:10:09 *REQUIRED A GREAT DEAL*
OF GEOLOGICAL TIME.
557 00:28:10:11 00:28:12:10 *HOWEVER,*
WHEN PALEONTOLOGISTS
558 00:28:12:12 00:28:14:25 *CAREFULLY EXAMINED*
THE FOSSIL RECORD
559 00:28:14:27 00:28:16:24 *LOOKING FOR*
THOSE INTERMEDIATES
560 00:28:16:26 00:28:20:25 *THAT WOULD OCCUR*
BETWEEN SPECIES,
561 00:28:20:27 00:28:23:10 *THEY COULDN'T FIND*
THESE INTERMEDIATES.
562 00:28:23:12 00:28:24:24 *MOST PALEONTOLOGISTS*
563 00:28:24:26 00:28:27:09 *BLAME LACK*
OF INTERMEDIATES
564 00:28:27:11 00:28:29:24 *ON AN INCOMPLETE*
FOSSIL RECORD,
565 00:28:29:26 00:28:31:21 *BUT AFTER MORE*
CAREFUL STUDY,
566 00:28:31:23 00:28:34:21 *THERE WAS A REALIZATION*
THAT THESE TRANSITIONAL FORMS
567 00:28:34:23 00:28:36:11 *SIMPLY DON'T EXIST.*
568 00:28:37:28 00:28:41:07 *THIS BROUGHT ABOUT THE IDEA*
OF PUNCTUATED EQUILIBRIUM.
569 00:28:41:09 00:28:44:10 *THAT ONCE*
A SPECIES APPEARED,
570 00:28:44:12 00:28:48:11 *IT LASTED FOR*
A LONG TIME UNCHANGED.
571 00:28:48:13 00:28:51:23 *THEN SUDDENLY, IN TERMS*
OF GEOLOGICAL TIME,
572 00:28:51:25 00:28:53:07 *A NEW SPECIES APPEARED,*
573 00:28:53:09 00:28:56:08 *AND THERE WAS VERY LITTLE,*
IF ANY, EVIDENCE
574 00:28:56:10 00:28:58:04 *FOR THE INTERMEDIATES.*
575 00:28:58:06 00:29:02:07 *TODAY, PUNCTUATED EQUILIBRIUM*
HAS BEEN ADDED
576 00:29:02:09 00:29:03:24 *TO DARWIN'S THEORY*
577 00:29:03:26 00:29:06:23 *TO ACCOUNT FOR CHANGE*
SEEN IN THE FOSSIL RECORD.
578 00:29:06:25 00:29:08:22 *NOT ONLY CAN LIFE*
EVOLVE GRADUALLY,
579 00:29:08:24 00:29:10:10 *BUT IN A WORLD*
580 00:29:10:12 00:29:13:01 *WHERE RAPID ENVIRONMENTAL*
CHANGE SOMETIMES OCCURS,
581 00:29:13:03 00:29:15:23 *RAPID EVOLUTION*
CAN ALSO TAKE PLACE.
582 00:29:15:25 00:29:18:23 *THE HISTORY OF LIFE*

583 00:29:18:25 00:29:21:08 *OVER GREAT LENGTHS OF TIME*
IS GOVERNED
 584 00:29:21:10 00:29:22:22 *BY THE NEED TO ADAPT*
 585 00:29:26:26 00:29:28:09 *OR DIE OUT.*
 586 00:29:28:11 00:29:31:08 DURING THE PLEISTOCENE,
 ICE-AGE MAMMALS
 587 00:29:31:10 00:29:33:23 DOMINATED THE CONTINENTS.
 THESE INCLUDED MASTODONS,
 588 00:29:33:25 00:29:36:08 MAMMOTHS,
 GROUND SLOTHS,
 589 00:29:36:10 00:29:39:08 AND SABER-TOOTH CATS.
 THEY SUDDENLY DISAPPEARED
 590 00:29:39:10 00:29:41:22 ABOUT 8,000 YEARS AGO.
 THE CAUSE OF THIS
 591 00:29:41:24 00:29:44:24 MASS EXTINCTION ISN'T KNOWN,
 BUT A LIKELY POSSIBILITY
 592 00:29:44:26 00:29:46:23 IS THE INCREASING EFFICIENCY
 593 00:29:46:25 00:29:49:07 OF HUMAN HUNTERS.
 OUR SPECIES IS, OF COURSE,
 594 00:29:49:09 00:29:51:06 VERY SUCCESSFUL,
 AND WE'VE ENJOYED
 595 00:29:51:08 00:29:53:21 A RAPID RISE IN POPULATION
 SINCE THE END
 596 00:29:53:23 00:29:56:06 OF THE LAST ICE AGE.
 BUT THE EVOLUTIONARY
 597 00:29:56:08 00:29:59:11 DEVELOPMENT OF HUMANS
 ISN'T WELL UNDERSTOOD BECAUSE
 598 00:29:59:13 00:30:02:05 HUMAN FOSSILS ARE SO RARE.
 THE MOST FAMOUS EXAMPLES
 599 00:30:02:07 00:30:03:21 OF AN ANCESTRAL SPECIES
 600 00:30:03:23 00:30:06:14 COME FROM AFRICA
 WHERE THE FIRST HUMANS
 601 00:30:06:16 00:30:09:21 MOST LIKELY EVOLVED.
 IT'S SOBERING AND AT
 602 00:30:09:23 00:30:12:21 THE SAME TIME EXHILARATING
 TO STARE INTO THE ABYSS
 603 00:30:12:23 00:30:15:06 OF GEOLOGIC TIME
 AND REALIZE
 604 00:30:15:08 00:30:17:22 THAT IT ALL BEGAN
 WITH TINY AND
 605 00:30:17:24 00:30:19:22 EXTREMELY SIMPLE ORGANISMS.
 ORGANISMS LIKE THESE
 606 00:30:19:24 00:30:22:20 GAVE RISE
 TO THE VAST VARIETY
 607 00:30:22:22 00:30:25:21 OF LIFE ON EARTH.
 THE RESILIENCE OF LIFE
 608 00:30:25:23 00:30:28:21 IS TRULY AMAZING
 WHEN WE CONSIDER
 609 00:30:28:23 00:30:31:05 THE MANY MASS EXTINCTIONS
 THAT HAVE OCCURRED
 610 00:30:31:07 00:30:32:22 THROUGHOUT EARTH HISTORY.
 THE LATEST MASS EXTINCTION
 611 00:30:32:24 00:30:34:21 MAY BE OCCURRING
 THIS VERY MOMENT.
 612 00:30:34:23 00:30:36:06 THE IMPACT OF HUMANS
 613 00:30:36:08 00:30:39:06 IS CAUSING SPECIES

614 00:30:39:08 OF BOTH PLANTS AND ANIMALS
 00:30:41:06 TO DISAPPEAR
 AT AN ASTOUNDING RATE.
 615 00:30:41:08 00:30:42:14 SCIENTISTS ESTIMATE
 616 00:30:42:16 00:30:44:21 A LARGER PERCENTAGE
 OF EARTH'S SPECIES
 617 00:30:44:23 00:30:47:06 WILL DISAPPEAR WITHIN
 OUR LIFETIME THAN WERE LOST
 618 00:30:47:08 00:30:49:16 DURING THE MASS EXTINCTION
 OF THE DINOSAURS.
 619 00:30:49:18 00:30:52:19 SOME PEOPLE THINK OF HUMANS
 AS THE FINAL PRODUCT
 620 00:30:52:21 00:30:55:05 IN A LONG PROCESS
 OF ORGANIC EVOLUTION.
 621 00:30:55:07 00:30:57:05 BUT OUR SPECIES
 IS ONE BRANCH
 622 00:30:57:07 00:30:59:19 ON THE EVOLUTIONARY
 TREE OF LIFE.
 623 00:30:59:21 00:31:01:04 ORGANIC EVOLUTION
 HAS OPERATED
 624 00:31:01:06 00:31:03:04 SINCE LIFE FIRST APPEARED
 ON EARTH,
 625 00:31:03:06 00:31:05:19 AND BECAUSE GEOLOGIC PROCESSES
 CONTINUOUSLY CHANGE
 626 00:31:05:21 00:31:07:19 CONDITIONS
 OF THE EARTH'S SURFACE,
 627 00:31:07:21 00:31:10:19 WE CAN ONLY IMAGINE
 WHAT LIFE WILL BE LIKE
 628 00:31:10:21 00:31:12:05 IN THE DISTANT FUTURE.
 629 00:31:14:07 00:31:17:04 CAPTIONING PERFORMED BY
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