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WHY THE EVOLUTIONARY EPIC MATTERS

0:01–0:40

HISTORY OF LIFE ON EARTH

Hi, I'm Emily Graslie and welcome to Crash Course Big History. Today we'll be discussing why the history of life on Earth is not just a distant curiosity for people who happen to be interested in dinosaurs and trilobites, but one deeply wrapped up in what it means to be human and a part of an ancient and fragile biosphere.

The history of life on Earth is a tale that spans from three point eight billion years ago with the appearance of the first single cell organisms. It starts with a very young Earth, charts the rise of complexity in the biosphere, and links our story to the rocks and flames of the inanimate cosmos.

The evolutionary epic is a story of fascinating beasts and dramatic changes. It is pieced together, similar to human history, by the hunt for evidence in order to construct a timeline of events.

0:40–1:36

EVIDENCE OF HISTORY

Much like historians, it is the job of palaeontologists to interpret that evidence. And a lot of that timeline remains a mystery. Presently, we're at a stage comparable to early Renaissance scholars rediscovering the history of the Roman Empire from long lost documents, except we are using fossils and evolutionary biology to explore the depths of an obscure past.

Humans have only been around for two hundred fifty thousand years, or 0.00006 percent of the evolutionary epic.

What's more, we are descended from ancestral species that lived millions and millions of years ago, right back to the origin of life, and their story is our story. And it's one that can teach us a lot about our lives today and the many pitfalls and perils of our future.

Since the Cambrian explosion of multi-cellular species five hundred forty-one million years ago, there have been 5 major mass extinctions:

1:36–2:00

MAJOR EXTINCTIONS

The First - the Ordovician extinction four hundred and fifty-five million years ago was caused by a rapid freezing period, followed in quick succession by a warming period killing off many inhabitants of the Earth that could not adapt fast enough.

Then the Devonian extinction three hundred and seventy five million years ago was caused either by an asteroid impact, nutrient pollution from evolving plants, a decrease in carbon dioxide due to plant dominance, volcanic activity, or all of the above.

The Permian extinction two hundred and fifty-two million years ago may have been caused by an asteroid impact, a natural increase in carbon dioxide, or the prevailing theory: super-volcanoes blocking out sunlight.

2:00–2:56

EXTINCTIONS CONT'D

The Permian is called the "Great Dying" because it was the worst extinction of species in the past 541 million years.

The Triassic extinction 201 million years ago was also likely due to volcanic super-eruptions or an asteroid impact.

And the Cretaceous extinction 65 million years ago, which wiped out most dinosaurs and led the way for an explosion of mammals, was caused by an asteroid.

We are now in the middle of the Sixth Mass Extinction. It is a disaster caused by us. Out of all the mass extinctions that have happened since the Cambrian explosion, the Sixth Mass Extinction is the first that has been caused by a single species- and it's our fault.

But it's not because we are evil, or diabolically powerful. But because we share the lessons of each generation to future generations in exquisite detail. And those lessons stack up and we get better and better at exploiting our ecosystems.

2:56–3:34

OUT OF AFRICA

This sixth extinction event isn't a recent thing either. Humans started the uptick in extinctions almost immediately. When we immigrated out of Africa 64,000 years ago, away from the African megafauna that had evolved alongside us, we began an evolutionary slaughter of non-African species that wiped out the majority of megafauna on every continent we visited.

Easy pickings for human hunters fell before us in Europe, Asia, North America, and especially Australia. Everything from woolly mammoths in Eurasia to giant kangaroos in Australia seem to have gone extinct shortly after humans arrived there.

This was not out of any malice or extraordinary strength, but because our skills were highly adaptive, and we were talented at getting what we needed to survive.

3:34–4:09

CAMBRIAN EXPLOSION

We can hardly blame our ancestors for not worrying about biodiversity or doing studies of animal populations 60,000 years ago.

When talking about the Sixth Mass Extinction, you're going to hear a lot about how this is the first one caused by a single species. And by contrast with the Ordovician, Devonian, Permian, Triassic, and Cretaceous -- that's more or less correct.

But there is another extinction event that we don't talk about enough. Allow me to take you back in time before the Cambrian explosion, well before multi-cellular species ever existed, about three billion years ago. Single cell organisms were the only life on Earth, dwelling in the oceans and evolving for hundreds of millions of years.

4:09–4:52

SLOWLY EVOLVING

Very slowly, over millions upon millions of years, bacteria rose nearer to the ocean surface. They evolved to convert sunlight, water, and carbon dioxide into energy. It was photosynthesis. And the waste product of this process was highly reactive oxygen.

Over the next billion years, photosynthesizing bacteria slowly increased the level of oxygen in the atmosphere. Not all single-celled life was capable of withstanding the harmful effects of oxygen, and many different species, all potential ancestors for more complex life, died off in droves.

While a mass extinction of bacteria may not appear as dramatic as an asteroid wiping out dinosaurs, it is significant because these highly successful genera squeezed out many other species by simply being well-equipped to extract energy and resources from the environment.

4:52–5:35

COLLECTIVE LEARNING

Humans, through the use of our collective learning, are very similar. We are so adept at getting what we need out of the environment, that we are leaving very little room for other species.

At the core of this is scarcity, and the limited amount of energy in the Universe upon which all complexity depends. Very often the success of one species must come at the expense of another. However, that is not all there is to the equation, since there are also many interdependencies in an ecosystem that can easily be upset.

For instance, those photosynthesizing bacteria in the oceans are still there capturing carbon dioxide and releasing oxygen. And if human-induced acidification of the oceans were to kill off much of this bacteria, carbon dioxide levels in the atmosphere would rise even faster than they are now, frustrating our attempts at combatting climate change.

5:35–6:18

THE GREAT OXYGENATION

That is why the prospect of a Sixth Mass Extinction is so scary. While extinctions happen all the time and are an essential part of evolution, if certain species are removed from an ecosystem, the entire house of cards can come crashing down, threatening even humans.

While The Great Oxygenation took hundreds of millions of years of slow gradual change, human-led extinctions are happening in a much smaller fraction of time, about 250,000 years. That might seem like a long time, but the rate seems to be accelerating with each rise of human complexity.

As devastating as human foraging was to many megafaunal species, once humans created agriculture, we started changing entire ecosystems to suit our needs. Human population numbers and density

began to rise dramatically, meaning more resources were consumed.

6:18–7:03

RISE OF AGRICULTURE

Forests were cut down to make way for crops and pasture. Predators that were a threat to humans and livestock were hunted down. And over-hunting and over-fishing by our exploding populations became a growing concern.

But if we can assign a date to when these extinctions became a mass extinction, the year 1500 is a pretty good candidate. Around this time, the age of Western explorations had begun. Humans travelled the world, started colonising new areas and building farms, and began hunting new species to extinction with improving technology. We introduced new invasive species and diseases that destabilised entire ecosystems.

We started a global homogenisation of flora and fauna, introducing our domesticates and off-shoots like rats and rabbits into environments where they still compete with native species that had evolved there for millions of years. Let's go to the Thought Bubble.

7:03–7:35

INUSTRIALIZATION

After the next rise of complexity, industrialisation, things skyrocketed even further.

Human populations have continued to climb from just shy of a billion people around the year 1800 to 7 billion today, and with projections that the human population will reach 9.5-10 billion by 2050.

With increased populations and increased industrialisation, the drop of biodiversity continues.

Since 1500, we are aware of somewhere between 330 and 620 major vertebrate species that have gone extinct. But that number may be as high as a thousand, and the majority of that happened in the past century. And it isn't just extinctions that are worrying.

7:35–8:22

DECLINING SPECIES

Since 1960, the wild vertebrate population that still exists has been cut in half. With fewer numbers comes a greater risk of extinction in the near future, as genetic diversity decreases and populations weaken.

Today, we use about 40% of the total land area of the world for human purposes, and only 15% of that land is preserved for environmental protection. The remaining 45% is still eligible for further human development. This is not enough to protect many threatened species.

Habitat loss is the primary problem for 85% of the species considered endangered today.

The oceans aren't faring any better: unsustainable and unregulated fishing and pollution kills off animals like sharks, tuna, whales, sea turtles, and thousands upon thousands of species that are dependent on coral reefs.

This doesn't even count the vast expanses of unexplored oceans, and the untold number of yet unde-

scribed species that may be affected.

8:22–9:16

75% REDUCTION?

If this trend continues perhaps 75% of all multicellular species could go extinct, and in a thousand years, the majority of life on Earth will be our domestic animals: dogs, cats, cows, sheep, crops, and animals that adapt to the environments we've created. Soon, raccoons may rule the earth!

Thanks, Thought Bubble.

The biosphere is a complex tangle, and it's true our global history is full of extinctions - and, in fact, is driven by them. It might seem we ought to just preserve the ones we need for our own survival, and forget the rest. But if one species which seems to have no direct importance to us were allowed to go extinct, it could potentially set off a domino effect that brings down an entire ecosystem.

Once ecosystems start collapsing, a ballooning human population of billions and billions of people might suffer more than just a little inconvenience. Our human population, especially the poorest of us, would experience some real threats to our food supplies, health, and our own livelihoods.

9:16–9:55

HOW TO RECOVER?

It's not quite so easy to recover from our mistakes, either. After a major extinction event, it usually takes the biosphere about ten to fifty million years to fully recover. Damage could be done within a few centuries that would take millions of years to undo.

As you might expect, one thing that makes the Sixth Mass Extinction even worse is carbon emissions, which has a planetary boundary of 350 parts per million before it starts causing permanent problems.

It's a boundary we have already crossed. Today we are hovering around 400 parts per million. The average global surface temperature will increase, affecting every ecosystem on the planet, but with continued emissions, the question is how high will it get?

9:55–10:57

2 DEGREES

The best case scenario, or our goal at any rate, is 2 degrees this century. Even that slight increase in so short a time could lead to the extinction of an estimated 33% of all species.

It will result in increased water shortages, recurrent dust bowls like the ones seen in North America in the 1930s, an uptick in climate refugees particularly from the Pacific, and sky-rocketing food prices that will afflict the world's poor while their populations continue expanding.

If the average global temperature gets any higher, the effects are even worse. At four degrees, which less optimistic forecasts think we'll reach by the end of the century, it may become impossible to grow crops in some regions of the world, and freshwater will become critically scarce for billions of people.

Bubbles of carbon and methane currently trapped

in frozen soil, like in Siberia and on the ocean floor, could escape from the thawing ground and start a runaway greenhouse effect that even our cutting back on emissions could not stop. At six degrees hotter, in the long run we may be looking at an extinction of Cretaceous or even Permian proportions. Another "Great Dying".

10:57–12:21

WHAT IS OUR LEGACY?

Does history repeat itself? With humanity, history is certainly not repeating itself given our uniqueness, but the outcome of our activities might be the same as the Permian Extinction. A similar disaster today could not only stall the rise of complexity, but destroy all the complexity humans have created in the past 250,000 years, or worse, silence the rise of complexity on Earth forever.

Looking at the entire evolutionary epic, it is just as well to think about what our legacy will be. I would hate to be classed by our struggling descendants and our geological record to be on par with an asteroid, a super-volcanic eruption, or even photosynthesizing bacteria- and that's because we have something that asteroids, volcanoes, and bacteria do not.

We have the ability to reflect and change our behaviour. And if we fail and cause just as much disaster as those apocalyptic scenarios, our failure is doubled because, at the end of the day, for one brief and shining moment, we had the power to stop it.

See you next time.