Why the Evolutionary Epic Matters: Crash Course Big History #203

Crash Course: Big History
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===== (00:00) to (02:00) =====

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 part of an ancient and fragile biosphere.

The history of life on Earth is a tale that spans from 3.8 billion years ago with the first appearance of single-celled 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's pieced together similar to the human history by the hunt of evidence in order to construct a timeline of events. Much like historians, it's the job of paleontologists to interpret that evidence. And a lot of that timeline remains a mystery.

Presently, we're at a stage comparable to the early Renaissance scholars rediscovering the history of the Roman Empire from long lost documents. Except we're using fossils and evolutionary biology to explore the depths of an obscure past.

Humans have only been around for 250,000 years, or 0.00006% of the evolutionary epic. What's more, we're 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.

(Crash Course theme)

Since the Cambrian explosion of multi-cellular species 541 million years ago, there have been five major mass extinctions. The first, the Ordivician extinction 455 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 couldn't adapt fast enough.

Then, the Devonian extinction 375 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.

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The Permian extinction 252 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. 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 lead the way for an explosion of mammals, was caused by an asteroid.

We are now in the middle of the Sixth Mass Extinction. It's a disaster caused by us. Out of all of 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're evil or diabolically powerful, but it's 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.

The Sixth Extinction Event isn't a recent thing either. Humans started the uptake in extinctions almost immediately. When we immigrated out of Africa 64 thousand 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 seemed 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. We can't hardly blame our ancestors for not worrying about biodiversity or doing studies of animal populations 60 thousand years ago.

When talking about the Sixth Mass extinction, you're gonna hear a lot about how this is the first one caused by a single species. And by contrast to the Ordovician, Devonian, Permian , Triassic, and Cretaceous that's more or less correct. But there's 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 3 billion years ago.

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Single-celled organisms were the only life on earth; dwelling in the oceans and evolving for hundreds of millions of years.

Very slowly, over millions upon millions of years, bacteria rose near to the ocean surface. They evolve 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 and 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 the process. While a mass extinction of bacteria may not appear as dramatic as an asteroid wiping out dinosaurs it is significant as these highly successful genera squeezed out many other species by simply being well-equipped to extract energy and resources from the environment.

Humans, through the use of our collective learning, are very similar. We're so adept at getting what we need out of the environment that we're 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 this is not all there is to the equation since there are also many inter-dependencies in an ecosystem that can easily be upset. For instance, those photosynthesizing bacteria in the ocean 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 combating climate change. That is why the prospect of a sixth mass extinction is so scary.

While extinctions happen all the time and is an essential part of evolution, if certain species are removed from the 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 and gradual change, human-led extinctions are happening at a much smaller fraction of time: about 250,000 years.

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That might seem like a long time, but the rate seem to be accelerating with each rise of human complexity.

As devastating as human activity was to many mega-faunal 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.

Forests were cut down to make way for crops and pasture, and predators that were a threat to humans and livestock were hunted down. And over-hunting and over-fishing by our exploding population began 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 colonizing new areas and building farms, and began hunting new species to extinction with improving technology. We introduced new invasive species and diseases that disrupted entire ecosystems.

We started a global homogenization of flora and fauna, introducing our domesticates and offshoots like rats and rabbits into environments where they still compete with native species that had evolved there for millions of years. Lets go to the thought bubble. After the next rise of complexity: industrialization, 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 to 10 billion by 2050. With increased populations and increased industrialization, the drop of biodiversity continues. Since 1500, we are aware of somewhere between 330 and 620 major vertebrate species that have gone extinct.

And it isn't just extinctions that are worrying; since 1960 the wild vertebrate population that still exist has been cut in half. With fewer number 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 the 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.

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And 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 undescribed species that may be affected. If this trend continues, perhaps 75% of all multi-cellular species could go extinct.

And in a thousand years, the majority of life on earth will be our domestic animal: dogs, cats, cows, sheep, crops, and animals that adapt to the environment we've created. Soon raccoons may rule the earth. Thanks thought bubble.

The biosphere is a complex tango and it's true that our global history is full of extinctions, and in fact is driven by them. It might seem like we ought to preserve the species we need for our own survival and forget the rest. But if one species which seems t have no direct importance to up 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 livelihood. It's not quite so easy to recover from these 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 have 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 about 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?

The best case scenario or, our goal at any rate, is 2 degrees this century.

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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 we saw in North America in the 1930s, an uptake in climate refugees, particularly from the pacific, and skyrocketing food prices that will inflict the world's poor while their populations continue expanding. If the average global temperature gets any higher, the effects are even worse: at 4 degrees, which less optimistic forecasters think we'll reach by the end of the century, it may become impossible to grow crops at some region of the world and fresh water 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 couldn't stop. At 6 degrees hotter, in the long run we may be looking at the extinction of Cretacious or even Permian proportions: another great dying. 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 can not only stall the rise of complexity, but destroy all the complexity humans have created in the past 250 thousand years. Or worse, silence the rise of complexity on earth forever.

Looking at the entire evolutionary epic, it's just as well to think 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, or 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 to 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.

Crash Course Big History is filmed in the Chad and Stacey Emigholz Studio in Indianapolis, Indiana and is produced with the help of all of these nice people. Our animation team is Thought Cafe.

===== (12:00) to (12:22) =====

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