10.0

THE HISTORY OF EVERYTHING

0:16–1:35
SCRAMBLED EGGS

First, a video. Yes, it is a scrambled egg. But as you look at it, I hope you'll begin to feel just slightly uneasy. Because you may notice that what's actually happening is that the egg is unscrambling itself. And you'll now see the yolk and the white have separated, and now they're going to be poured back into the egg. And we all know in our heart of hearts that this is not the way the Universe works.

A scrambled egg is mush, tasty mush, but it's mush. An egg is a beautiful, sophisticated thing that can create even more sophisticated things, such as chickens. And we know in our heart of hearts that the Universe does not travel from mush to complexity.

In fact, this gut instinct is reflected in one of the most fundamental laws of physics, the second law of thermodynamics, or the law of entropy. What that says basically is that the general tendency of the Universe is to move from order and structure to lack of order, lack of structure—in fact, to mush. And that's why that video feels a bit strange.

1:35–2:29
VAST COMPLEXITY

And yet, look around us. What we see around us is staggering complexity. Eric Beinhocker estimates that in New York City alone, there are some ten billion SKUs or distinct commodities being traded. That's hundreds of times as many species as there are on Earth. And they're being traded by a species of almost seven billion individuals who are linked by trade, travel and the Internet into a global system of stupendous complexity.

So here's a great puzzle. In a Universe ruled by the second law of thermodynamics, how is it possible to generate the sort of complexity I've described, the sort of complexity represented by you and me and the convention center?

2:29–3:24
GOLDILOCKS CONDITIONS

Well, the answer seems to be the Universe can create complexity, but with great difficulty. In pockets, there appear what my colleague Fred Spier calls Goldilocks Conditions. Not too hot, not too cold, just right for the creation of complexity and slightly more complex things appear. And where you have slightly more complex things, you can get slightly more complex things.

And in this way, complexity builds stage by stage. Each stage is magical because it creates the impression of something utterly new appearing almost out of nowhere in the Universe. We refer in Big History to these moments as threshold moments. And at each threshold, the going gets tougher. The complex things get more fragile, more vulnerable. The Goldilocks Conditions get more stringent and it's more difficult to create complexity.

3:24–4:26

IMAGINE NOTHING

Now, we as extremely complex creatures desperately need to know the story of how the Universe creates complexity despite the second law and why complexity means vulnerability and fragility. And that's the story that we tell in Big History. But to do it, you have to do something that may at first sight seem completely impossible. You have to survey the whole history of the Universe. So let's do it.

Let's begin by winding the timeline back 13.7 billion years to the beginning of time. Around us, there's nothing. There's not even time or space. Imagine the darkest, emptiest thing you can and cube it a gazillion times, and that's where we are.

4:26–4:57

BIG BANG

And then suddenly, BAM, a Universe appears, an entire Universe and we've crossed our first threshold. The Universe is tiny, it's smaller than an atom, it's incredibly hot, it contains everything that's in today's Universe.

So you can imagine, it's busting and it's expanding at incredible speed. And at first, it's just a blur, but very quickly distinct things begin to appear in that blur. Within the first second, energy itself shatters into distinct forces, including electromagnetism and gravity.

4:57–5:46

THE FIRST SECOND

And energy does something else quite magical. It congeals to form matter, quarks that will create protons and leptons that include electrons. And all of that happens in the first second.

Now, we move forward 380,000 years. That's twice as long as humans have been on this planet. And now, simple atoms appear of hydrogen and helium.

Now, I want to pause for a moment, 380,000 years after the origins of the Universe, because we actually know quite a lot about the Universe at this stage. We know above all that it was extremely simple. It consisted of huge clouds of hydrogen and helium atoms and they have no structure. They're really a sort of cosmic mush. But that's not completely true.

5:46–6:22

GRAVITY

Recent studies by satellites such as the WMAP satellite have shown that in fact there are just tiny differences in that background. What you see here, the blue areas are about a thousandth of a degree cooler than the red areas. These are tiny differences, but it was enough for the Universe to move on to the next stage of building complexity.

And this is how it works. Gravity is more powerful where there's more stuff. So where you get slightly denser areas, gravity starts compacting clouds of hydrogen and helium atoms.

6:22–7:26

STARS AND ELEMENTS

So we can imagine the early Universe breaking up into a billion clouds. And each cloud is compacted, gravity gets more powerful as density increases, the temperature begins to rise at the center of each cloud, and then at the center of each cloud, the temperature crosses the threshold temperature of 10 million degrees, protons start to fuse, there's a huge release of energy, and, BAM, we have our first stars. From about 200 million years after the Big Bang, stars begin to appear all through the Universe, billions of them.

And the Universe is now significantly more interesting and more complex. Stars will create the Goldilocks Conditions for crossing two new thresholds. When very large stars die, they create temperatures so high that protons begin to fuse in all sorts of exotic combinations to form all the elements of the periodic table. If, like me, you're wearing a gold ring, it was forged in a supernova explosion.

7:26–8:32

EARTH & OUR SOLAR SYSTEM

So now the Universe is chemically more complex. And in a chemically more complex Universe, it's possible to make more things. And what starts happening is that around young suns, young stars, all these elements combine. They swirl around, the energy of the star stirs them around, they form particles, they form snowflakes, they form little dust motes, they form rocks, they form asteroids and eventually, they form planets and moons.

And that is how our Solar System was formed four-and-a-half billion years ago. Rocky planets like our Earth are significantly more complex than stars because they contain a much greater diversity of materials. So we've crossed a fourth threshold of complexity.

Now, the going gets tougher. The next stage introduces entities that are significantly more fragile, significantly more vulnerable, but they're also much more creative and much more capable of generating further complexity. I'm talking, of course, about living organisms.

8:32–9:10

LIFE

Living organisms are created by chemistry. We are huge packages of chemicals. So, chemistry is dominated by the electromagnetic force that operates over smaller scales in gravity which explains why you and I are smaller than stars or planets. Now what are the ideal conditions for chemistry? What are the Goldilocks Conditions?

Well, first, you need energy, but not too much. In the center of a star, there's so much energy that any atoms that combine, will just get busted apart again. But not too little. In intergalactic space, there's so little energy the atoms can't combine. What you want is just the right amount.

9:10–10:12

MORE GOLDILOCKS CONDITIONS

And planets, it turns out are just right because they're close to stars, but not too close. You also need a great diversity of chemical elements and you need liquids, such as water. Why? Well, in gases, atoms move past each other so fast that they can't hitch up. In solids, atoms stuck together. They can't move. In liquids, they can cruise and cuddle and link up to form molecules.

Now, where do you find such Goldilocks Conditions? Well, planets are great and our early Earth was almost perfect. It was just the right distance from its star to contain huge oceans of liquid water. And deep beneath those oceans at cracks in the Earth's crust, you got heat seeping up from inside the earth and you got a great diversity of elements. So at those deep oceanic vents, fantastic chemistry began to happen. And atoms combined in all sorts of exotic combinations.

10:12–11:01

DNA IS INFORMATION

But, of course, life is more than just exotic chemistry. How do you stabilize those huge molecules that seem to be viable? Well, it's here that life introduces an entirely new trick. You don't stabilize the individual, you stabilize the template—the thing that carries information—and you allow the template to copy itself. And DNA, of course, is the beautiful molecule that contains that information.

You'll be familiar with the double helix of DNA. Each rung contains information. So DNA contains information about how to make living organisms. And DNA also copies itself, so it copies itself and scatters the templates through the oceans. So the information spreads.

11:01–11:40

DNA LEARNS

Notice that information has become part of our story. The real beauty of DNA though, is in its imperfections. As it copies itself, once in every billion rungs, there tends to be an error. And what that means is that DNA is in effect learning. It's accumulating new ways of making living organisms because some of those errors work. So DNA is learning and it's building greater diversity and greater complexity.

And we can see this happening over the last four billion years. For most of that time of life on Earth, living organisms are being relatively simple single cells, but they had great diversity and inside great complexity.

Then from about 600 to 800 million years ago, multicelled organisms appear. You get fungi, you get fish, you get plants, you get amphibia, you get reptiles, and then, of course, you get the dinosaurs.

11:40–12:23

THE DINOSAURS DISAPPEAR

And occasionally, there are disasters. 65 million years ago, an asteroid landed on Earth near the Yucatan Peninsula creating conditions equivalent to those of a nuclear war, and the dinosaurs were wiped out. Terrible news for the dinosaurs, but great news for our mammalian ancestors who flourished in the niches left empty by the dinosaurs.

12:23–13:13

HOMO SAPIENS APPEAR

And we human beings are part of that creative evolutionary pulse that began 65 million years ago with the landing of an asteroid. Humans appeared about 200,000 years ago. And I believe we count as a threshold in this great story. Let me explain why.

We've seen that DNA learns in a sense. It accumulates information, but it is so slow. DNA accumulates information through random errors that just some of which just happened to work. But DNA had actually generated a faster way of learning. It had reproduced organisms with brains, and those organisms can learn in real time. They accumulate information, they learn. The sad thing is, when they die, the information dies with them.

13:13–13:48

HUMAN LANGUAGE

Now what makes humans different is human language. We are blessed with a language, a system of communication so powerful and so precise that we can share what we've learned with such precision that it can accumulate in the collective memory. And that means it can outlast the individuals who learnt that information and it can accumulate from generation to generation. And that's why as a species we're so creative and so powerful and that's why we have a history. We seem to be the only species in four billion years to have this gift.

13:48–14:20

COLLECTIVE LEARNING

I call this ability "collective learning". It's what makes us different. We can see it at work in the earliest stages of human history. We evolved as a species in the savanna lands of Africa. But then you see humans migrating into new environments, into desert lands, into jungles, into the ice aged tundra of Siberia. Tough, tough environment. Into the Americas, into Australasia. Each migration involved learning, learning new ways of exploiting the environment, new ways of dealing with the surroundings.

14:20–15:22

AGRICULTURE AND THE MODERN REVOUTION

Then 10,000 years ago, exploiting a sudden change in global climates, with the end of the last ice age, humans learned to farm. Farming was an energy bonanza. And exploiting that energy, human populations multiplied, human societies got larger, denser, more interconnected. And then, from about 500 years ago, humans began to link up globally, through shipping, through trains, through telegraph, through the Internet, until now we've seem to form a single global brain of almost seven billion individuals and that brain is learning at warp speed.

And in the last 200 years, something else has happened. We've stumbled on another energy bonanza in fossil fuels. So fossil fuels and collective learning together explain the staggering complexity we see around us. So, here we are back at the convention center.

15:22–16:08

A NOTE OF CAUTION

We've been on a journey—a return journey of 13.7 billion years. I hope you'll agree this is a powerful story. And it's a story in which humans play an astonishing and creative role, but it also contains warnings.

Collective learning is a very, very powerful force and it's not clear that we humans are in charge of it. I remember very vividly as a child growing up in England, living through the Cuban missile crisis. For a few days, the entire biosphere seemed to be on the verge of destruction. And the same weapons are still here and they're still armed. If we avoid that trap, others are waiting for us.

16:08–16:58

FUTURE THREATS

We're burning fossil fuels at such a rate that we seem to be undermining the Goldilocks Conditions that made it possible for human civilizations to flourish over the last 10,000 years.

So what Big History can do is show us the nature of our complexity and fragility and the dangers that face us. But it can also show us our power with collective learning.

And now, finally, this is what I want. I want my grandson, Daniel, and his friends and his generation throughout the world to know the story of Big History. And to know it so well, that they understand both the challenges that face us and the opportunities that face us.

16:58–17:29

FREE ONLINE COURSE

And that's why a group of us are building a free online syllabus in Big History for high school students throughout the world. We believe that Big History will be a vital intellectual tool for them, as Daniel and his generation face the huge challenges and also the huge opportunities ahead of them at this threshold moment in the history of our beautiful planet.

I thank you for your attention.