10.0THE HISTORY OF FVFRYTHING

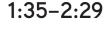
0:16-1:35 First, a video. Yes, it is a scrambled egg. But as you look at it, I hope you'll begin to feel just slightly uneasy. SCRAMBLED EGGS Because you may notice that what's actually happening is that the egg is unscrambling itself. And you'll now see the yolk and the white have separated, and now 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.

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 bil- VAST COMPLEXITY lion 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?

Well, the answer seems to be the Universe can create 2:29-3:24 complexity, but with great difficulty. In pockets, there appear what my colleague Fred Spier calls Goldi- GOLDILOCKS locks Conditions. Not too hot, not too cold, just right CONDITIONS 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 impres-

BIG HISTORY PROJECT

sion 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

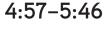
Now, we as extremely complex creatures desperately need to know the story of how the Universe creates **IMAGINE NOTHING** complexity despite the second law and why complexity means vulnerability and fragility. And that's the story that we tell in Big History. But to do it, you have to do something that 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 And then suddenly, BAM, a Universe appears, an entire Universe and we've crossed our first thresh-**BIG BANG** old. 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.

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 hap- THE FIRST SECOND pens 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.

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 **GRAVITY** 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.

5:46-6:22

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.

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 tem- STARS AND ELEMENTS perature begins to rise at the center of each cloud,

6:22 - 7:26

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 So now the Universe is chemically more complex. And in a chemically more complex Universe, it's pos-EARTH & OUR SOLAR sible to make more things. And what starts happen-**SYSTEM** ing 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 fourand-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 intro-

duces 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.

Living organisms are created by chemistry. We are 8:32-9:10 huge packages of chemicals. So, chemistry is dominated by the electromagnetic force that operates over LIFE 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.

And planets, it turns out are just right because they're 9:10-10:12 close to stars, but not too close. You also need a great diversity of chemical elements and you need liquids, MORE GOLDILOCKS such as water. Why? Well, in gases, atoms move past CONDITIONS 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.

But, of course, life is more than just exotic chemis-

10:12-11:01

try. How do you stabilize those huge molecules that DNA IS INFORMATION 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.

> Notice that information has become part of our story.

11:01-11:40

The real beauty of DNA though, is in its imperfec-DNA LEARNS tions. 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 THE DINOSAURS then, of course, you get the dinosaurs.

11:40-12:23

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.

And we human beings are part of that creative evo- 12:23-13:13 lutionary pulse that began 65 million years ago with the landing of an asteroid. Humans appeared about HOMO SAPIENS 200,000 years ago. And I believe we count as a APPEAR 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

Now what makes humans different is human lan- 13:13-13:48 guage. We are blessed with a language, a system of communication so powerful and so precise that we HUMAN LANGUAGE 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 I call this ability "collective learning". It's what makes

us different. We can see it at work in the earliest stag-**COLLECTIVE LEARNING** es 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 Then 10,000 years ago, exploiting a sudden change in global climates, with the end of the last ice age, AGRICULTURE humans learned to farm. Farming was an energy AND THE MODERN bonanza. And exploiting that energy, human popula-**REVOUTION** tions 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.

We've been on a journey—a return journey of 13.7 bil- 15:22-16:08 lion years. I hope you'll agree this is a powerful story. And it's a story in which humans play an astonishing A NOTE OF CAUTION 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.

We're burning fossil fuels at such a rate that we seem 16:08-16:58 to be undermining the Goldilocks Conditions that made it possible for human civilizations to flourish over the FUTURE THREATS 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.

And that's why a group of us are building a free online syllabus in Big History for high school students FREE ONLINE COURSE throughout the world. We believe that Big History will be a vital intellectual tool for them, as Daniel and his

16.58-17.29

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.