# Indralaya talk 4 - The Big Bang

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(from https://www.nationalgeographic.com/science/article/origins-of-the-universe)

Okay so how did we get here anyway? Here's another story for us to consider:

> In the first 10^-43 seconds of its existence, the universe was very compact, less than a million billion billionth the size of a single atom. It's thought that at such an incomprehensibly dense, energetic state, the four fundamental forces—gravity, electromagnetism, and the strong and weak nuclear forces—were forged into a single force, but our current theories haven't yet figured out how a single, unified force would work. To pull this off, we'd need to know how gravity works on the subatomic scale, but we currently don't.
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> It's also thought that the extremely close quarters allowed the universe's very first particles to mix, mingle, and settle into roughly the same temperature. Then, in an unimaginably small fraction of a second, all that matter and energy expanded outward more or less evenly, with tiny variations provided by fluctuations on the quantum scale. That model of breakneck expansion, called inflation, may explain why the universe has such an even temperature and distribution of matter.
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> After inflation, the universe continued to expand but at a much slower rate. It's still unclear what exactly powered inflation.
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> As time passed and matter cooled, more diverse kinds of particles began to form, and they eventually condensed into the stars and galaxies of our present universe.
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> By the time the universe was a billionth of a second old, the universe had cooled down enough for the four fundamental forces to separate from one another. The universe's fundamental particles also formed. It was still so hot, though, that these particles hadn't yet assembled into many of the subatomic particles we have today, such as the proton. As the universe kept expanding, this piping-hot primordial soup—called the quark-gluon plasma—continued to cool. Some particle colliders, such as CERN's Large Hadron Collider, are powerful enough to re-create the quark-gluon plasma.
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> Radiation in the early universe was so intense that colliding photons could form pairs of particles made of matter and antimatter, which is like regular matter in every way except with the opposite electrical charge. It's thought that the early universe contained equal amounts of matter and antimatter. But as the universe cooled, photons no longer packed enough punch to make matter-antimatter pairs. So like an extreme game of musical chairs, many particles of matter and antimatter paired off and annihilated one another.
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> Somehow, some excess matter survived—and it's now the stuff that people, planets, and galaxies are made of. Our existence is a clear sign that the laws of nature treat matter and antimatter slightly differently. Researchers have experimentally observed this rule imbalance, called CP violation, in action. Physicists are still trying to figure out exactly how matter won out in the early universe.

> Within the universe's first second, it was cool enough for the remaining matter to coalesce into protons and neutrons, the familiar particles that make up atoms' nuclei. And after the first three minutes, the protons and neutrons had assembled into hydrogen and helium nuclei. By mass, hydrogen was 75 percent of the early universe's matter, and helium was 25 percent. The abundance of helium is a key prediction of big bang theory, and it's been confirmed by scientific observations.
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> Despite having atomic nuclei, the young universe was still too hot for electrons to settle in around them to form stable atoms. The universe's matter remained an electrically charged fog that was so dense, light had a hard time bouncing its way through. It would take another 380,000 years or so for the universe to cool down enough for neutral atoms to form—a pivotal moment called recombination. The cooler universe made it transparent for the first time, which let the photons rattling around within it finally zip through unimpeded.
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> We still see this primordial afterglow today as cosmic microwave background radiation, which is found throughout the universe. The radiation is similar to that used to transmit TV signals via antennae. But it is the oldest radiation known and may hold many secrets about the universe's earliest moments.
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> There wasn't a single star in the universe until about 180 million years after the big bang. It took that long for gravity to gather clouds of hydrogen and forge them into stars. Many physicists think that vast clouds of dark matter, a still-unknown material that outweighs visible matter by more than five to one, provided a gravitational scaffold for the first galaxies and stars.
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> Once the universe's first stars ignited, the light they unleashed packed enough punch to once again strip electrons from neutral atoms, a key chapter of the universe called reionization. In February 2018, an Australian team announced that they may have detected signs of this "cosmic dawn." By 400 million years after the big bang, the first galaxies were born. In the billions of years since, stars, galaxies, and clusters of galaxies have formed and re-formed—eventually yielding our home galaxy, the Milky Way, and our cosmic home, the solar system.
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> Even now the universe is expanding, and to astronomers' surprise, the pace of expansion is accelerating. It's thought that this acceleration is driven by a force that repels gravity called dark energy. We still don't know what dark energy is, but it's thought that it makes up 68 percent of the universe's total matter and energy. Dark matter makes up another 27 percent. In essence, all the matter you've ever seen—from your first love to the stars overhead—makes up less than five percent of the universe.

This no less far out, don't you think, than Raven stealing the sun from Gray Eagle, or the story of Genesis. This is the theory of the so-called big bang. It was born of the observation that other galaxies are moving away from our own at great speed in all directions, as if they had all been propelled by an ancient explosive force.

A Belgian priest named Georges Lemaître first suggested the big bang theory in the 1920s, when he theorized that the universe began from a single primordial atom. The idea received major boosts from Edwin Hubble's observations that galaxies are speeding away from us in all directions, as well as from the 1960s discovery of cosmic microwave radiation—interpreted as echoes of the big bang—by Arno

Penzias and Robert Wilson. It's the theory that so far makes the best sense to scientists and it's quite well accepted.

And it's a theory. A theory that explained the observable situation. The biggest things it helps explain are that galaxies are speeding away from each other and all the observations agree that if you figure out the directions they're going now and how old they are they all started at the same point. And there are tons of other technical things like a kind of cosmic background radiation that's everywhere that the big bang explains.

But it's interesting to think about theory and the idea of "truth." Sometimes you hear people say, disparagingly way, "it's that *just* a theory?" But actually theories are usually all we have. About everything. We just get so used to them and take them for granted as "true."

Like when I looked out the window yesterday morning expecting to see my wet shoes - my theory was that they were there based on the evidence of my memory of leaving them there - and suddenly that theory had to be abandoned when the evidence - no shoes seen - contradicted it, and I had to create a new theory. "Someone moved the shoes" and that did explain the evidence. But did I see that someone move the shoes? No. Did I confirm my theory by asking around? Nope. So it's a theory, not an observable truth but it sure seems pretty reliable based on everything else I myself know about the universe. And I supported my theory with a theory about the motivation of our unknown shoe-mover: they are thoughtfully helping out so we wouldn't all get wet shoes if it started raining.

And so it is with the big bang theory. Can we go back in time and space and watch it happen? Well I can't even go back in time and watch the wonderful person who moved our shoes inside yesterday morning and at least yesterday morning human beings existed. At the time of the big bang no life existed. Even the matter that could make up life didn't exist. There is no observing this one. And there's no observing most things that are "true" - well, what does true even mean? No was observing and directly verifying most of our many theories.

Pretty wild theory though. A look back into the unknown. The first conceivable moment of the universe. Was that the actual beginning of the universe? What happened before that moment when the expansion - the big bang - began? What was there before this insanely dense, hot, primordial quantum soup?

Does the idea of a *before* even make sense? One wild thing about this understanding is that it's NOT that there was space here before the big bang, like a big canvas into quick the universe sprung. There was nothing. It's universe itself that expanded out. Space itself wasn't here and then it was. And physics talks about space-time as the two are radically intertwined so time wasn't here either. So can there be a time before time?

And that tale of the big bang left us so very far in the distance past. Galaxies full of stars formed. And to bring us briefly forward remember how stars run by fusing light hydrogen atoms together - hydrogen is the most simple kind of atom once things settled down enough in the early universe even to have atoms. A hydrogen atom just has one proton to make up its nucleus and one electron bouncing around it. Remember how once stars got big enough their massive gravity enabled hydrogen atoms to mash - to fuse - together creating helium and releasing tons of energy? Well once that gets going the helium atoms start mashing together too forming bigger more complex atoms, and those mash together. It's a mess in there. We know from how the different elements are structured what some of the cosmic recipes are like if you fuse a carbon atom and a helium atom you get an oxygen atom. Some of the bigger and more complex elements require even more crazy stuff like stars going through their entire life cycles to become weird stuff like neutron stars which if they end up smashing together in space create more new stuff.

All this stuff getting created and flung about and smashed together and being attracted to each other's masses and somehow we end up with the Earth spinning around our sun in the middle of it's 10 billion year lifespan.

And then we can start the extremely unlikely story of life and the very far out theory of evolution.

Basically the diversity of life on earth, including us, is one big, very unlikely, series of chance events. Maybe the simplest way of saying it is that it was all a big mistake. But what a wonderful mistake. What a wonderful cacophony of many mistakes and changes and chance events that led us here. 30 something different humans each with their own unique but overlapping structures. There are probably 200 to 300 bird species that live on or pass through this property at one point or another. A dozen tree species. A few dozen mammal species. I'm not sure how many regular (vascular) plant species - a little under 1000 maybe. I did learn that there are 224 species of moss on the San Juan islands as a whole. Hundreds to thousands of species of fungi. All kinds of microbial life in the soils. It would be a massive scientific enterprise to make an accurate and complete list of all of the types of living stuff that lives on Indralaya's 80 something acres.

And the root idea of all of this incredible diversity is mistakes. Errors. When the genetic building blocks of cells - protein strands we call DNA - get copied when stuff reproduces the copy isn't perfect. It's a bio-chemical process in a fluid situation inside the water-filled cells. It all works incredibly well, the copies are super accurate for the most part but not perfectly.

And, as you know, when something changes at this lower level - DNA - is can lead to changes at higher levels, the shapes and functions of cells. And then multiple those changes out to complex organizations of cells that can work together to do things like motion, or digestion, even thinking, and a gazillion other processes that living beings do.

I was reading about a simple bacteria that biology education usually uses to help us get a sense of the complexity of human life. E.g. if it's this complicated in a little bacteria…

Anyway the E. coli bacteria is just a single cell. Bound by a membrane - remember how water is needed for the membrane to hold together - inside is a single long strand of DNA with 4 million base pairs of genetic info. 4 million and his is one of the simplest living things there is. Also inside there are about 1,000 different special proteins called enzymes that can do different jobs that bacteria needs doing. Like e. coli "eats" sugars - one is called maltose. There's a particular enzyme that breaks a maltose molecule into two simpler glucose molecules. So the E. coli uses a section of it's DNA to make a maltose eating enzyme. And then it needs another enzyme to break the glucose molecules down into simpler molecules than produce the energy the cells needs for all of these processes. No brain, no poetry, but a sophisticated responsive system that allows the cell to do what it needs to do to perpetuate itself and reproduce. And when it does reproduce you get pretty much just a new E. coli just like the last one but….maybe a little different. And some of those different ones do better than others. Add in a diversity of situations they life in - habitat - and then these differences matter even more. This pond, or this part of the ocean,  a bacteria that's can do X does better, but in that other place where it's warmer or there's more of something or less of something, a bacterial that can do Y does better.

So it's not just random change in reproducing organisms. It's also interaction with a dynamic, changing, and diverse environment that adds up to natural selection.

And on it went as simpler organisms getting tweaked and changed on an Earth that's radically changed in so many ways over 3 or 4 billion years you end up with all of this.

With the amazing trees on this property. Mostly here we have Douglas-firs, Western red-cedars, and Madrona with a scattering of other species. And of course these magnificent apple trees which I learned were planted by the settlers who cleared this meadow - this would have all been forest here - before Indralaya came along. About 120 years old these apple trees.

And all of it made from the stuff of stars and helped along by essential properties of these atoms and molecules like the way water molecules stick together.

It's easy to see how essential that is to trees. Somehow moisture has to get from the ground to the leaves, or needles, of a tree 100 feet up in the air. Trees don't have little pumps in them. It's essential here the way water molecules can stick together because of their polarity. In in the tiny tubes in the wood a couple of layers in from the bark  long chains of water molecules are sucked up like sucking from a straw. What starts the sucking? Evaporation - transpiration really - where the energy of the sun draws water out of teeny-tiny holes in the leaves. Those holes have to be really tiny because it turns out that you need a massive amount of pressure to pull water up a 100 foot tree so we need them those water molecules not just fly out all at once. We need them to work for it. In a tall tree the upper parts of this water sucking system have pressures as low as negative 15 atmospheres in order to suck water all that way up. If you put some water in a straw and suck really hard you can only life it about 30 feet so trees have to have some intricate details of their plumbing just right to get the massively low pressure they need at the top for the water to keep rising up against gravity.

I could go on obviously: we could each do many PhD's in biology, chemistry, and physics and barely scratch the surface of the amazing story of an ordinary day on the planet surrounded by these amazing elements, systems, and life forms.

And how unlikely it all is! Just on the personal level you can easily think of a thousand reasons why you might not be here at this retreat much less why you might not have lived this long or ever existed. And then add in how unbelievably unlikely it is that a life form like this - a human being - evolved. And then add in how amazingly lucky we are to end up with a planet about the right distance away from the pounding energy of the sun so it's not too hot and not too cold. A fact we're appreciating more now that we've found out that just changing the chemistry of the atmosphere up with a bit more carbon is messing things up so much since now the earth is holding onto a bit more of the heat from the sun than it used to after it bounces off the surface. That's a big problem for sure. But if the earth had been a bit closer to Venus or Mars we would never have had life here in the first place.

And yet here we are. We aren't perfect, that's for sure. And we are of the nature to grow old, get sick, and die, that's hard on us. But we're here. We're here right now. Can we live with a bit more appreciation for this incredibly wondrous multi-layered miraculous set of events that got us and the rest of this living planet here at this moment?

By the way I was thinking about the 4th of Buddhism's 5 remembrances and I realized there is something important left out. Just to remind us here's the full set in traditional wording.

1. I am of the nature to grow old. There is no way to escape growing old.
2. I am of the nature to have ill health. There is no way to escape having ill health.
3. I am of the nature to die. There is no way to escape death.
4. All that is dear to me and everyone I love are of the nature to change. There is no way to escape being separated from them.
5. My actions are my only true belongings. I cannot escape the consequences of my actions. My actions are the ground upon which I stand.

#4 - everything I love will change and vanish. Sure enough. And new things I love will appear too. Dear friends will die and new babies will be born. The sun sets and it also rises. Relationships fail, this is sad an incredibly painful - I was married 29 years myself, and new relationships somehow form. Life within change is difficult and wonderful together. We need a new word that means both together - diffiwonderful? Wonderficult?

This earth does seem to be in trouble - difficult - and it will also change and adapt in ways we can't yet know. Let's hold the hope while we also accept the suffering that we humans will do even better than usual support our neighbors and realizing that our loved ones includes everyone - love all the people - and all being whales are people. We do see this and see it regularly with people under stress in disasters they perform incredible acts of altruism. Yes we also see the opposite: Buddhism says our conditioned mind has some deep roots in desire, anger, and confusion. We're realistic about the challenges ahead but that doesn't mean we have to be pessimistic. The mind is capable of so much. And maybe our studying what an extraordinary thing everything actually is this week will help our minds and the minds of those we know and love to remember our incredible potential along with our frequent stumbles and confusions.

[notes on post retreat: sensitive to the stress of others, depression dip, new realizations, major decisions, trust the unfolding]

[notes on tomorrow morning: wrap up the formal practice before breakfast so we can hang out, get packed (cabins clean!) and out by 11am in easy time for the 12:25pm ferry that's a 10 minute drive away. And no need to get all rushed and hyper but you probably will, ah well].

[thank yous: Indralaya staff, chores, MNW staff, Norman, Jon Kabat-Zinn, Saki, Florence & Melissa, our parents and teachers, including the ones who didn’t do it all so well: may we learn and grow as we heal from whatever damage we received from them]

[staying with the practice for the rest of the day, holding the silence which we're doing so well]