Deep time: Where are we in the universe?

Presented by John M. Pawelek
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Reading 1: "14 May 1905" *from* Einstein's Dreams, Alan Lightman
Reading 2: Genesis I. (verses 1-7)

Looking into the night sky we see planets, stars, galaxies and more. But perplexingly, what we see is in the past. Light takes time to reach us. Traveling at 186,000 miles/second it takes 8 minutes to get here from the sun. I remember being shocked in the 5th grade to learn that the sun could go out or explode and we wouldn't know it for 8 minutes. But 8 minutes is almost nothing compared to many stars and galaxies that are so far away that by the time the light reaches us we are seeing what they looked like millions and even billions of years ago. That's a long time. And that isn't even deep! Infinite is deep.

We humans tend to make assumptions about time: 1) that clocks measure time at the same rate; 2) that time can be divided basically into past and future, with the past over and gone. In fact, both assumptions are false.

Weird effects described by Einstein happen to time as soon as people or things move with respect to each other. Time itself slows down for the fast traveler. There is nothing wrong with the clocks—the effect is real. Time also moves slower as gravity increases. Time stops altogether in the center of black holes where gravity is massive.

We also learned from Einstein that time does not exist alone. It is merged with space as "spacetime". This room exists both in space and in time and the two are inseparable. You have to think about it, but it makes sense.

*"Deep Time" title from David Darling's book of the same name.

For us and our universe, time began with the big bang explosion about 14 billion years ago. There was no time before that. Apparently out of nothingness, the Big Bang created everything we know in the universe. Hydrogen generated from this event makes up some 70% of our bodies. And from gigantic stars that were formed and later exploded came the atoms of life: carbon, nitrogen and more. Such a star is called a Supernova. Life is possible because of Supernovae and their stardust.

The size of the universe is unimagineable. There are 100 billion galaxies containing about 100 billion stars per galaxy. 10,000 billion stars. But huge as this number seems, there is now considerable reason to believe that ours is not the only universe. We are only one of an unimaginably large number of "pocket" universes that together form the Mega-universe.

And more confounding, chemistry as we know it would likely vary between pocket universes with some 10^{500} variations. This latter point comes from string theory (or "brane" theory as it is sometimes called), a mathematical theory of <u>all existence</u> that is as yet incomplete. But its early achievements are providing startling glimpses into never worlds we cannot yet comprehend.

String theory predicts that there are some 11 dimensions, not just the 3 or 4 (if you include time) we know about.

And we now know that space is not empty. 95% of our universe is made up of a mysterious substance called dark matter. And perhaps the most bewildering of all, our universe is filled with another mysterious entity called dark energy. It accounts for 70% of energy in the universe. Imagine a rope with a person pulling one end as if in a tug of war. The other end, however, is suspended in space with no one pulling. Yet the tug of war goes on. Dark energy isn't tugging, it is pushing our galaxies away from each other at an accelerating rate. Yet we have no idea where the source of the force is coming from. Dark matter and dark energy are both in this room right now, and we have no idea where or what they are!

And here is a starting new concept in astrophysics that arises from this—as our universe expands it creates new existence.

These things are difficult for us to comprehend and sound bewildering. They imply that there is truly more going on than meets the eye. Two illustrate how I look at it, here is a story of a wasp on my side view mirror. I was parked by a lake in the summer. I could comprehend her, but she couldn't comprehend me. As far as she was concerned I was in a different dimension. She might be able to sense the breeze from my hand as being different from all other breezes she has ever known, but couldn't know it's source. Our perceptions of dark energy and dark matter are something like that—we know they exist but we don't know their source. Maybe we are still in for some surprises!

But we are very different from wasps. We have learned quite a bit in our brief time on Earth. What is it that allows us to both comprehend the wasp and to discover the nature of the universe? Of course it is our brain, a remarkable organ that strongly distinguishes us from the rest of the living world, at least on our planet.

With all the mysteries of the cosmos, the origin of life and the emergence of the human brain are just remarkable. Where did we come from?

About 4 billion years ago, Earth was formed from. Soon after that, when it got cool enough, water formed (about 3.9 billion years ago). As the earth cooled, water became liquid, forming seas, lakes, ponds and rivers. Somehow life formed in the water, beginning as a single-celled organism. The origin of life remains as mysterious as the origin of the Big Bang. For the first cell to give rise to descendents it had to have the capabilities of cell division. A first cell, arising for the first time in a tidal pool and able to duplicate itself. This would have required many thousands of complex molecules working in concert. Nothing like this has been achieved in the laboratory and there are no satisfactory explanations as to how it may have happened. It is a very improbable event. In the case of life on Earth, there hasn't been enough time. And remarkable in its own right is what followed after this--the wonderful story of evolution, every bit as astonishing and beautiful as our story of the universe.

It wasn't until about 125, 000 years ago that our ancestors appeared. They can be traced to Africa. A very brief time genetically compared to the 3.9 billion years of evolution it took to get to us. Our written history in the West is about 5000 years old—the Bible, although art and music came well before that. Cave paintings throughout the world date back 20-40,000 years ago. And early flute-like instruments appeared before that. We now

populate the entire world and constitute a single human race. Our basic human traits seem not to have changed significantly since our beginnings.

But ours is the first generation to understand that the miraculous story of life on Earth has a molecule as its central character: DNA. Because of its ability to self-replicate and the fact that the replication is not perfect and mutations occasionally occur, DNA has the ability to adapt to changing environments.

One of the most awesome features of this process is that during evolution, the DNA molecule continues to gain greater and greater complexity as new bits of genetic information are added. By assembling genes for the design of the human brain, DNA has surely reached a pinnacle, for it has created a method to comprehend itself! With the development of the human brain, DNA encodes our abilities for abstract thinking, language, imagination, creativity, art, music, culture and an unquenchable thirst for more knowledge. We are incredibly curious, and we have discovered that knowledge begets more knowledge. Knowledge is autocatalytic. We impulsively observe, record, project, and create. It seems we will not rest until all is understood. No mean feat for a molecule!

Moreover, with knowledge, we have learned to adapt without changing our genes. Instead of changing, we created machines. These abilities became possible with the development of abstract thinking and language—particularly the language of mathematics. In developing mathematics we truly differentiated ourselves from our ancestors. Monkeys can leap unerringly from tree to tree, but Newton with his laws of motion described in mathematical form how they do it. Then just when all seemed understood, Einstein and quantum mechanics have turned us on our ears. Atomic particles can be in more than one place at the same time. Particles from which we are made! At least one class of particles, antiquarks, can travel backwards in time. And, as we learned above, time is not only that which we mark with our watches, but a real entity that is affected by speed and gravity. That has beginnings and endings. Through mathematics we learn that our psychological arrow of time from past to future might be meaningless. From Stephen Hawking:

"In real time, the universe has a beginning and an end, but in mathematical imaginary time, there are no boundaries. So maybe what we call imaginary time is really more basic, and what we call real is just an idea that we invent to help us describe what we think the universe is like."

So as smart as we are, it seems that it is still not possible for us to understand time at this stage of our development. Try to make sense of how you got from last Sunday to this Sunday. A week passed, but what was it that passed? We invented hours and minutes but we don't know what it is they measure. And in questions of the origin of time, we can't comprehend infinity nor can we comprehend that time began with the Big Bang. There was no space or matter before then so there was no spacetime. And other pocket universes have their own beginnings of time.

As perplexing as this is to us, I would think that our descendents will have a better intuition for these things—a feeling of what time is. Like our children and grandchildren today who are instant experts at computers and cyberspace.

Today, however, we have a way to go before we get a feel for infinity and for nothingness. These are illusive thoughts that don't compute very well in our brains. In this regard, I have always been moved by a quote about time from Don Juan, the main character in Carlos Castenada's famous tales of the mysterious shaman from Mexico:

"I am going to utter perhaps the greatest piece of knowledge anyone can voice," said don Juan. "Do you know that at this very moment you are surrounded by eternity? And do you know that you can use that eternity, if you so desire?"

"There! Eternity is there! he said, pointing to the horizon. Then he pointed to the zenith. "Or there, or perhaps we can say that eternity is like this," extending his arms to the east and west."

"Do you know that you can extend yourself forever in any of the directions? "Do you know that one moment can be eternity? This is not a riddle; it is a fact."

And eerily similar are the lines from TS Elliot:
"We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time."

In closing I quote astronomer Abraham Loeb in the November, 2006 Scientific American. "When I look up into the sky at night, I often wonder whether we humans are too preoccupied with ourselves. There is much more to the universe than meets the eye on earth. As an astrophysicist I have the privilege of being paid to think about it, and it puts things in perspective for me. There are things that I would otherwise be bothered by—my own death, for example. Everyone will die sometime, but when I see the

universe as a whole, it gives me a sense of longevity. I do not care so much about myself as I would otherwise, because of the big picture."

Closing Words: Hearing a crow, the first one in a long time, I listened to it, deeply and with pleasure. And I thought, "What if I were dead, lying there dead, and I heard that! *from* Mary Oliver.

Benediction: Go in peace, believe in peace, create peace.