Tips for Helping a General Audience Understand Time

Ideas for helping Cosmic Café speakers and moderators make the topic of Time accessible

Physicists and lay audiences often think about *The Fabric of the Cosmos* topics differently. As a result, the challenge is to break the scientific ideas down in ways that make sense to lay audiences. Below are some ideas for helping people see how physicists approach the topic of Time.

As you (or your invited speaker) prepare your 10–12 minute presentation, consider organizing your remarks so that the audience will leave understanding the **Key Message**. Also, one goal of the *Cosmic Cafe* outreach campaign is to help people understand how *cosmic* topics relate to their lives. The **Relevance** section provides ideas for connecting the show's theme to people's lives. Use the **Conversation-Starter Questions** as ways to kick off a general discussion.

Key Message for Time

The universe flows from being organized to being disorganized. "Time" is the name we give to the process of having things go from being orderly and organized to being messy and disorganized. The Big Bang represents the universe's most highly ordered state, and the universe has grown increasingly disordered ever since. Since recreating the universe's earlier states of higher order is impossible, it's also impossible to return to an earlier time.

Relevance to people's lives

Time travel? Reverse the aging process? Glimpse the future? Technology grows out of an understanding of the cosmos. As scientists have learned to define, measure, and manipulate forces and processes in nature (e.g., gravity, electromagnetism, chemistry, genetics, quantum mechanics, etc.), we have been able to develop new technologies. Electronics, gene therapy, medicine, transportation, food production, and high-tech structures all draw on our understanding of fundamental principles. Similarly, time is a fundamental quantity. Understanding its true nature will enable us to develop new, and as of yet, unimagined technologies.

Big idea #1: Time is change

Everyday understanding: Time measures the passage of predictable, repetitive processes, such as Earth orbiting the sun, the moon orbiting Earth, Earth's rotation, the vibration of a crystal or an atom, etc.

Physicist's understanding: Time is change, but it is more than just local changes, such as a day or year. Instead, time is a process of the universe going from a highly ordered, high-energy state (i.e., the Big Bang) to a disordered, low-energy state. Technically, the universe's *entropy*—how evenly a system's energy is distributed—is increasing.

Concrete example: A clock measures the rate at which certain phenomena change or happen, such as a second being 32,768 oscillations of a watch's quartz crystal. People establish a standard for time by agreeing on which phenomena they will measure. This gives us days, months, years, etc. Another way to say it is that the "universe clock" started ticking 14 billion years ago and is still going. Every time unit (day, month, year, century) is a subunit of universe time. However, being able to measure the passage of time doesn't tell you what time is.

From the show: "Without change, we don't really have time. If you don't have events happening, it's hard to see how you would even imagine that there was time."

CONVERSATION-STARTER: WHAT IS TIME?

Big idea #2: Time is variable

Everyday understanding: Time is fixed. Each second is the same throughout the world, solar system, and universe.

Physicist's understanding: Time is variable. According to Einstein, motion and gravity can change time. The faster you go or the greater the gravitational force, the more time slows down for you when compared to someone else who is not moving or is not experiencing a strong gravitational force.

Concrete example: The show's narrator describes an experiment where an atomic clock on a jet plane ran more slowly than a second atomic clock remaining on the ground. He also mentions that time runs more quickly for a person at the top of a tall skyscraper than for someone on the ground floor, where the gravitational force is greater. Also, the GPS satellite system that lets your car or cell phone know where you are would not work accurately without careful correction for these effects.

CONVERSATION-STARTER QUESTION: IS TIME FIXED OR VARIABLE?

Big idea #3: Time flows from past to future

Everyday understanding: Time flows from the past to the future.

Physicist's understanding: Time flows from the past to the future. However, the mathematical equations related to time work just as well forward as backwards. Time equations can remain valid whether either positive or negative values for time are used. For physicists, the mathematics of time opens the possibility of traveling back into the past as well as forward into the future. However, the tendency of things to move from order to disorder runs only in one direction.

Concrete example: For the equivalence of running time forward and backward, imagine seeing a movie of a ball flying through the air between two people. If you didn't see the people throwing and catching, but just the ball, you would not be able to tell if the film was running forward or backward. On the other hand, the tendency of everything in the universe is to always move from order to disorder. For example, a tossed deck of cards scatters, ice melts, eggs break, smoke spreads through a room, glass shatters. Returning things to their original, ordered state is virtually impossible.

From the show: The Big Bang represents the universe's most ordered state. After that, things grew increasingly disordered, with the universe unwinding ever since. The Big Bang gives us a reason why the universe might look different when we look back in time versus forward, and why the "*arrow of time*" runs in one direction. Time is the name we give to the process of having things go from being orderly and organized to being messy and disorganized. "Time" can be thought of as riding the "wave" of increasing disorganization in the universe, and this wave defines the past, present, and future.

CONVERSATION-STARTER QUESTION: WHY DOES TIME SEEM TO MOVE TOWARD THE FUTURE?