# Science Journalism: Using Science Literacy to Teach Fundamental Science

Barb Mattson (Adnet/GSFC)
Jim Lochner (USRA/GSFC)

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Science Education and Outreach: Forging a Path to the Future

# Problem: You want to present a complex science topic to high school students…let's say dark energy.

- How do you tackle it?

# Take it to the teachers!

- Presented Beyond Einstein science to a focus group of teachers
- Needed science readings for their classrooms
- Impressed with how science changes with new data and new technology

# Germ of an Idea

- Chose to tell the story of dark energy by creating readings and lessons for students
  - This could work for **any** modern science topic
  - Weave science history and science literacy with fundamental science concepts
  - Illustrate the process of science
- Decided that a series of newspaper articles would accomplish all of these goals

# Cosmic Times is Born

- What discoveries led up to our current understanding of dark energy?
- What stories do we need to tell for students to understand the overarching “dark energy” story?
- Are there key dates that we can tie into?

➠ Ask the experts! We asked several cosmologists to sent 5-10 key developments from the past century that were critical to the discovery of dark energy

# Cosmic Times Dates

- 1919 - Confirmation of Einstein's Theory of Gravity
- 1929 - Hubble's discovery of Expanding Universe
- 1955 - Debate between Big Bang and Steady State
- 1965 - Discovery of the Cosmic Microwave Background
- 1993 - COBE Results; Development of Inflation Theory
- 2006 - Grappling with Dark Energy

# Science Threads

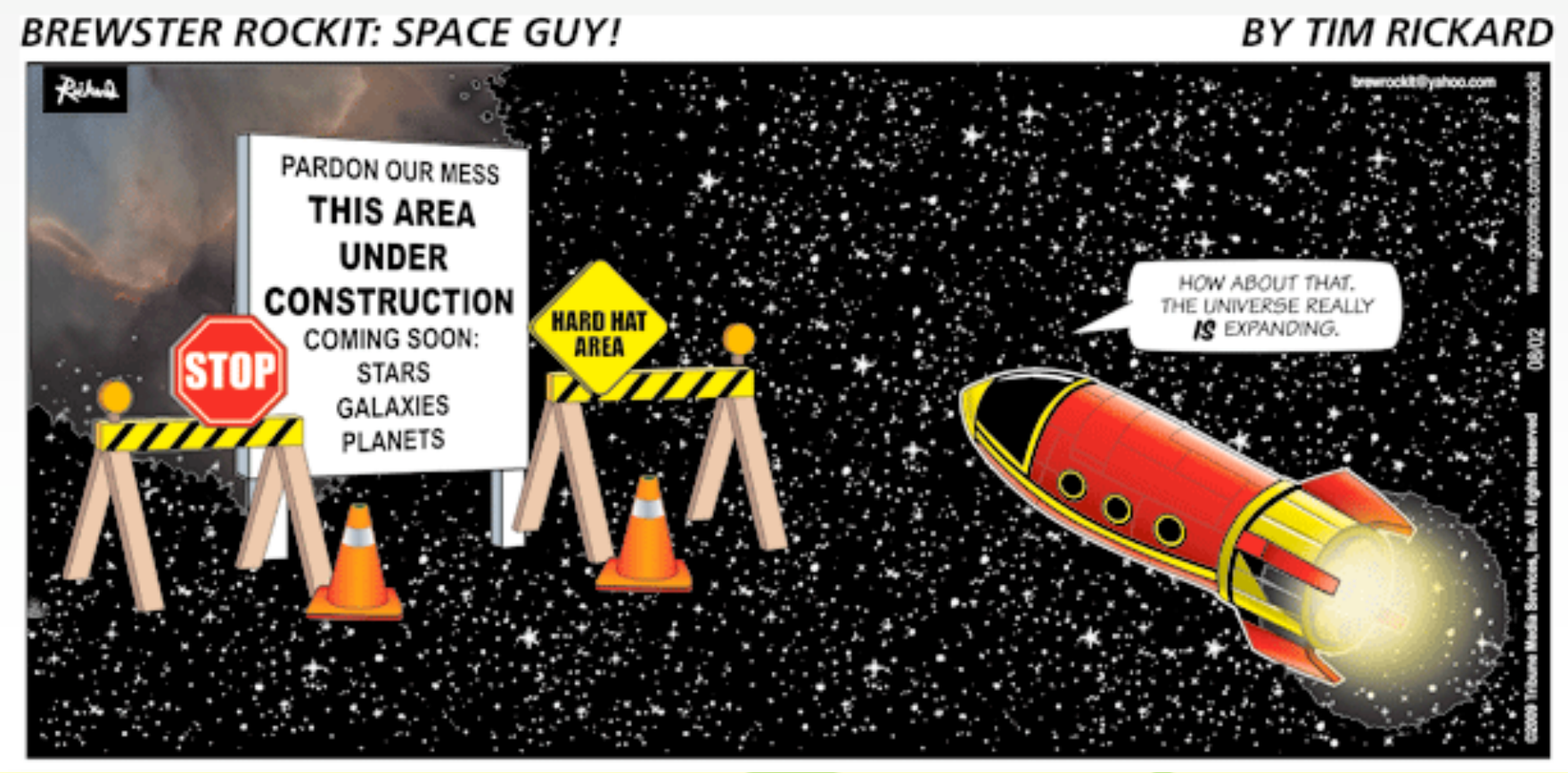
- It became clear that the story of the dark energy encompassed three different threads:
  - Nature of the expanding universe
  - Distances in the Universe/ Size of the Universe
  - Nature of supernovae and their use as standard candles

# The Real Work Begins…

- Once we had the specific stories, we were ready for the real work
  - Writing the articles
  - Developing lesson plans
  - Evaluating the success of our work

# Cosmic Times

## - Expanding Universe -



# The year is 1919…

- What's going on?
- What's going on in science?
- What is your view of the Universe?

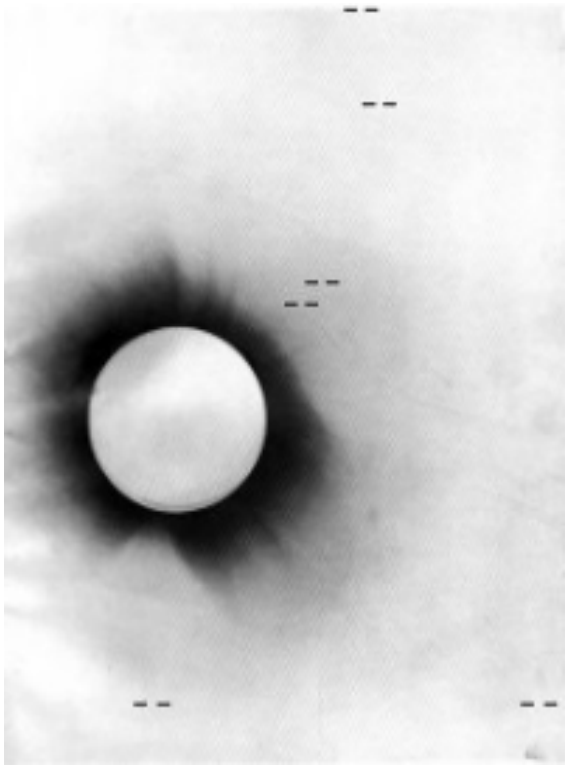
❇ Infinite

❇ Unchanging/static

❇ Ageless

# Enter Einstein

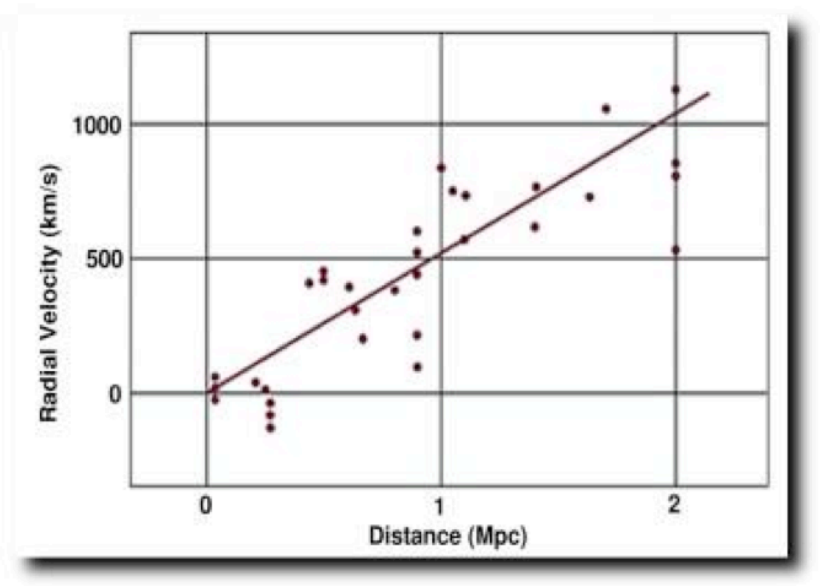
- What is Gravity?
- Gravity is curved space-time.
  - Gravity bends light.
  - Amount of deflection differs from Newton's prediction.
    - 1919 Solar Eclipse verified Einstein's prediction.



Fundamental science concepts: motions of the Earth, Moon & Sun, solar eclipse, gravity, curved space-time

# Expanding Universe

- Vesto Slipher showed the “nebulae” were red-shifted.
  - I.e. moving very fast away from us.
- Hubble put together the redshifts with their distances.




Hubbles' Original Data

Universe is expanding!

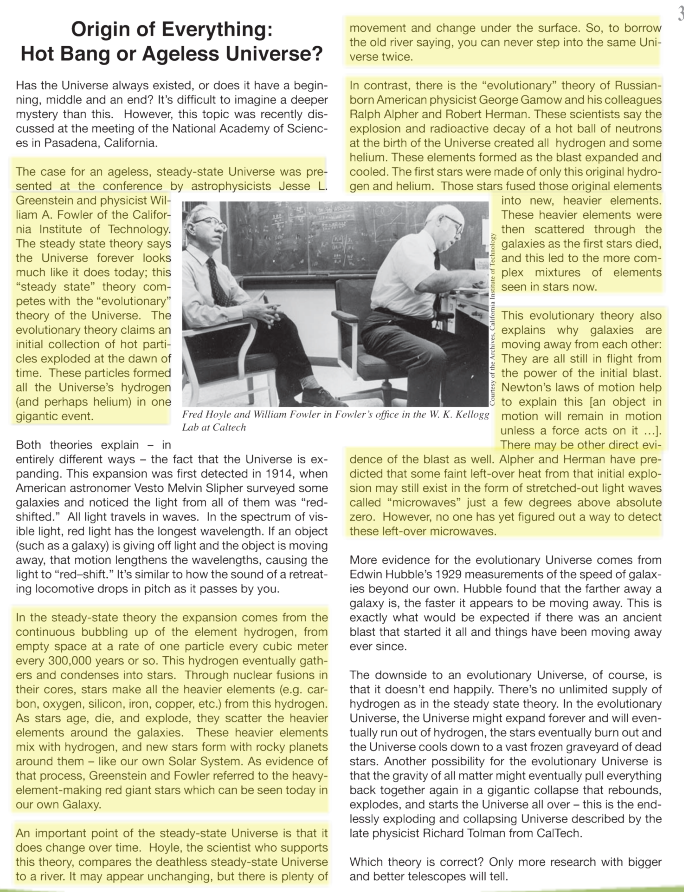
Fundamental science concepts: redshift, distance to galaxies, Cepheid variables (patterns in data)

# Reading Strategies

- Use one of the reading strategies to understand the CT article “Origin of Everything”

# Reading Strategy: Reciprocal Teaching

- Pair up
- Both partners read the same paragraph
- Have one partner summarize the paragraph for the other
- The other partner "checks and perfects" – state what you agree with, question parts you don't understand, add more information, connect ideas
- Read the next paragraph and switch roles
- Continue with each paragraph until you've read and understood the article



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**Origin of Everything: Hot Bang or Ageless Universe?**

Has the Universe always existed, or does it have a beginning, middle and an end? It's difficult to imagine a deeper mystery than this. However, this topic was recently discussed at the meeting of the National Academy of Sciences in Pasadena, California.

The case for an ageless, steady-state Universe was presented at the conference by astrophysicists Jesse L. Greenstein and physicist William A. Fowler of the California Institute of Technology. The steady state theory says the Universe forever looks much like it does today; this "steady state" theory competes with the "evolutionary" theory of the Universe. The evolutionary theory claims an initial collection of hot particles exploded at the dawn of time. These particles formed all the Universe's hydrogen (and perhaps helium) in one gigantic event.

*Fred Hoyle and William Fowler in Fowler's office in the W. K. Kellogg Lab at Caltech*

Courtesy of the Archives, California Institute of Technology

Both theories explain – in entirely different ways – the fact that the Universe is expanding. This expansion was first detected in 1914, when American astronomer Vesto Melvin Slipher surveyed some galaxies and noticed the light from all of them was "red-shifted." All light travels in waves. In the spectrum of visible light, red light has the longest wavelength. If an object (such as a galaxy) is giving off light and the object is moving away, that motion lengthens the wavelengths, causing the light to "red-shift." It's similar to how the sound of a retreating locomotive drops in pitch as it passes by you.

In the steady-state theory the expansion comes from the continuous bubbling up of the element hydrogen, from empty space at a rate of one particle every cubic meter every 300,000 years or so. This hydrogen eventually gathers and condenses into stars. Through nuclear fusions in their cores, stars make all the heavier elements (e.g. carbon, oxygen, silicon, iron, copper, etc.) from this hydrogen. As stars age, die, and explode, they scatter the heavier elements around the galaxies. These heavier elements mix with hydrogen, and new stars form with rocky planets around them – like our own Solar System. As evidence of that process, Greenstein and Fowler referred to the heavy-element-making red giant stars which can be seen today in our own Galaxy.

An important point of the steady-state Universe is that it does change over time. Hoyle, the scientist who supports this theory, compares the deathless steady-state Universe to a river. It may appear unchanging, but there is plenty of movement and change under the surface. So, to borrow the old river saying, you can never step into the same Universe twice.

In contrast, there is the "evolutionary" theory of Russian-born American physicist George Gamow and his colleagues Ralph Alpher and Robert Herman. These scientists say the explosion and radioactive decay of a hot ball of neutrons at the birth of the Universe created all hydrogen and some helium. These elements formed as the blast expanded and cooled. The first stars were made of only this original hydrogen and helium. Those stars fused those original elements into new, heavier elements. These heavier elements were then scattered through the galaxies as the first stars died, and this led to the more complex mixtures of elements seen in stars now.

This evolutionary theory also explains why galaxies are moving away from each other: They are all still in flight from the power of the initial blast. Newton's laws of motion help to explain this [an object in motion will remain in motion unless a force acts on it …]. There may be other direct evidence of the blast as well. Alpher and Herman have predicted that some faint left-over heat from that initial explosion may still exist in the form of stretched-out light waves called "microwaves" just a few degrees above absolute zero. However, no one has yet figured out a way to detect these left-over microwaves.

More evidence for the evolutionary Universe comes from Edwin Hubble's 1929 measurements of the speed of galaxies beyond our own. Hubble found that the farther away a galaxy is, the faster it appears to be moving away. This is exactly what would be expected if there was an ancient blast that started it all and things have been moving away ever since.

The downside to an evolutionary Universe, of course, is that it doesn't end happily. There's no unlimited supply of hydrogen as in the steady state theory. In the evolutionary Universe, the Universe might expand forever and will eventually run out of hydrogen, the stars eventually burn out and the Universe cools down to a vast frozen graveyard of dead stars. Another possibility for the evolutionary Universe is that the gravity of all matter might eventually pull everything back together again in a gigantic collapse that rebounds, explodes, and starts the Universe all over – this is the endlessly exploding and collapsing Universe described by the late physicist Richard Tolman from CalTech.

Which theory is correct? Only more research with bigger and better telescopes will tell.

Do Paragraphs 2, 4, 5, 6, 7

# Summarize Articles

- What do you know about the steady state theory from the readings?
- What do you know about the evolutionary theory of the universe from the readings?

# What is the Evidence?

## Bowl of Evidence

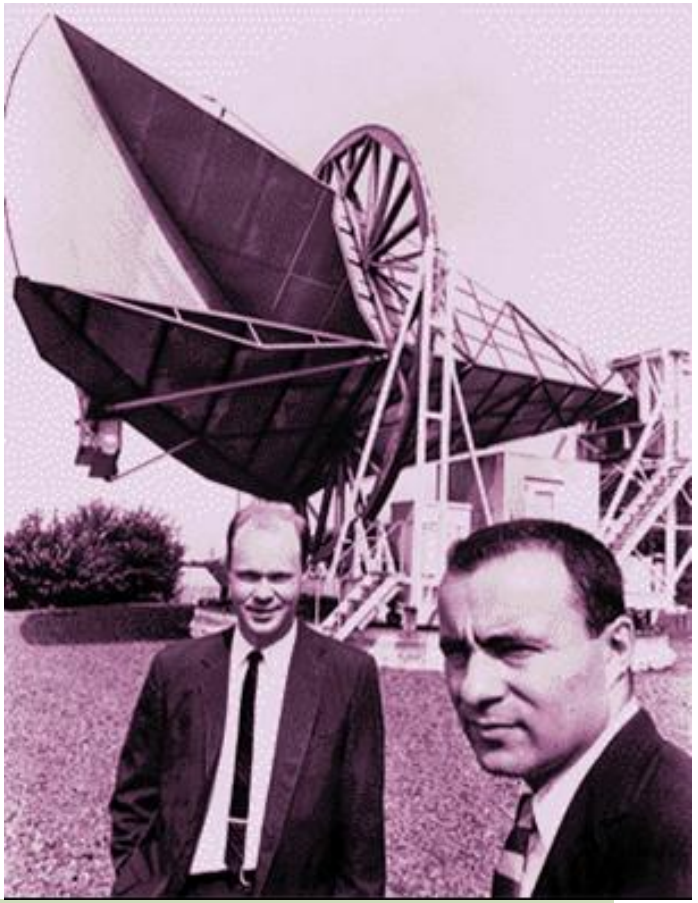
Scientists sort through theories by examining Evidence and making Inferences

# Steady State vs. Big Bang

- Resolution of Steady State vs Big Bang won't come until the mid-to-late 1960s.
- But as a competing theory, the Steady State provides the impetus to make observations to test the theories.
- Note that this lesson can be adapted for **any** science topic where there are two (or more) competing theories

# Breaking the Stalemate

- A hot “bang” should leave left-over heat.
- Data and theory came together in 1965
  - Penzias and Wilson found a mysterious 3 K residual noise while making radio observations of the Milky Way.
  - Peebles and Dicke (Princeton) had just calculated an estimate for the temperature of the residual background in the microwave region.



Fundamental science concepts: spectra, electromagnetic spectrum, origin of the Universe

# Cosmology's End?

- By the mid-90s, cosmologists thought that they had only to "fill in the details".
- Remaining questions:
  - Will the expansion continue forever, or will Universe eventually collapse back on itself?
  - What is the mass-density of the Universe (which would answer the above)?

# Cosmology's End?

- Things may not be what they seem.
- When we see odd behavior, we look more carefully at what's going on.

# Not the End In 1997…

- Gravity is the longest-reaching force according to physics
- SO, the expansion of the Universe should be slowing down…
- By observing supernovae in distant galaxies, researchers determine that the expansion is

Cosmologists get **very** excited

Fundamental science concepts: expanding universe, distances in the universe, supernovae, gravity

# History of the Universe's Expansion

Video clip from DVD *Beyond the Solar System: Expanding the Universe in the Classroom*, produced for NASA by the Harvard-Smithsonian Center for Astrophysics. © Smithsonian Institution

# The year is 2009…

- What's going on?
- What's going on in science?
- What is your view of the Universe?

- Finite
- Changing
- 13.7 Billion Years Old

# Summing up Our Methodology

- Choose a key discovery to trace
- Define discoveries that have contributed to the current understanding
- Identify key concepts and fundamental science
- Write the stories
  - Pick dates to best highlight the discoveries
- Develop lesson plans
  - Solidify fundamental science
  - Highlight multidisciplinary topics
  - Use real data

# Your Turn!

# Tell a science story…

- What stories could you tell?
  - your ideas

# Tell a science story…

- What stories could you tell?

  - your ideas

  - dark matter
  - gravitational waves
  - Pluto's planet status
  - exoplanets
  - cosmic-rays
  - water on Mars
  - global warming
  - computers (a technology story)
  - DNA
  - dinosaur mass extinction

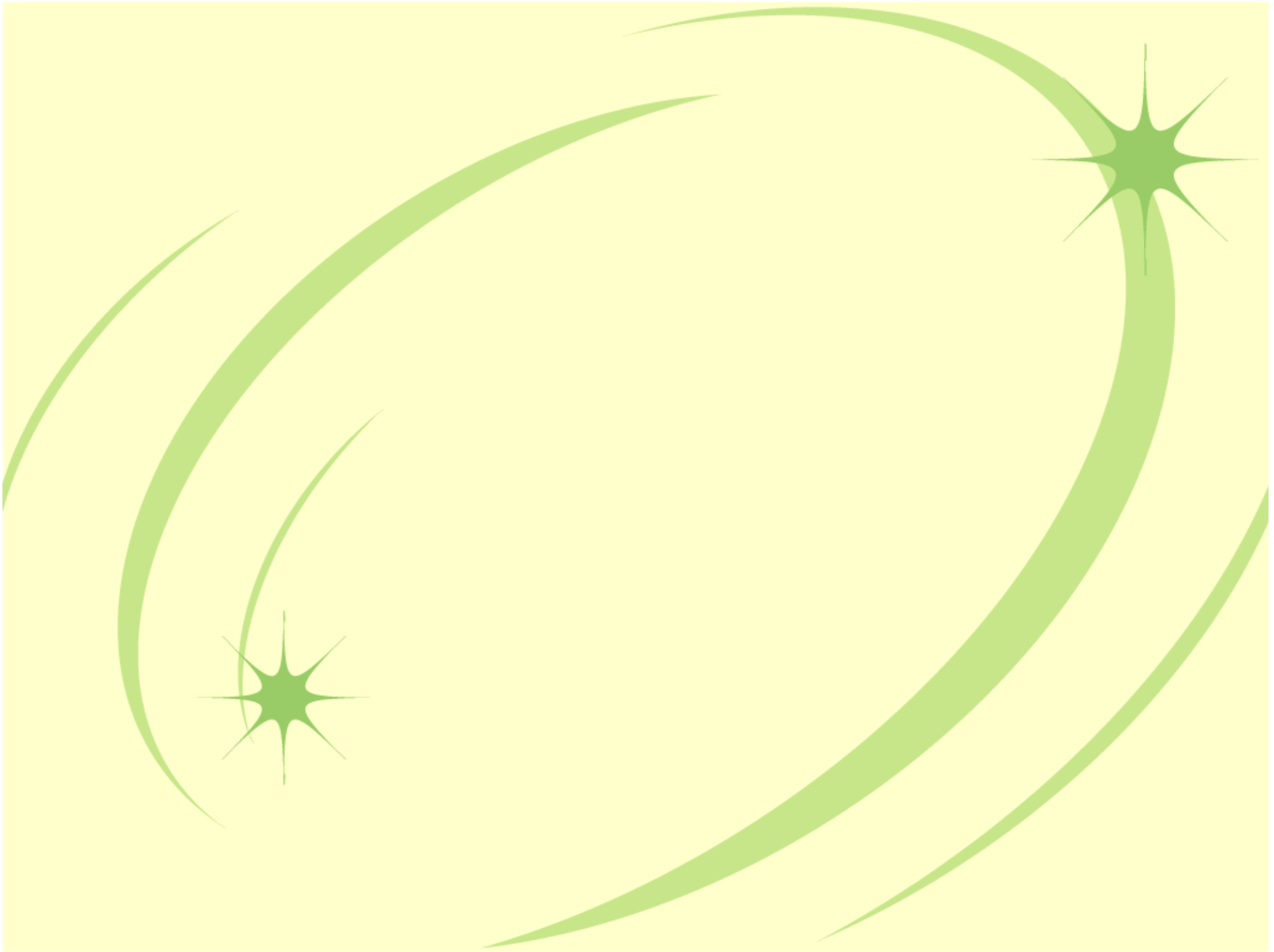
# Share

- (and Enjoy!)

# Cosmic Times

## http://cosmictimes.gsfc.nasa.gov/


Posters, Newsletters, Teacher Guide, Lessons



# Reading Strategy: Talking to the Text

- Individually read through the article “Hoyle Scoffs at ‘Big Bang’ Universe Theory”
- As you read, make notations to the text
  - Questions you might have
  - Words you don’t understand
  - Connections to other ideas
  - Responses to the text
  - Anything goes!

4 *“Genius” continued from page 1*

understand, test and apply his theories. There is his revolutionary re-thinking of light as not just waves but particles. Then his theory of special relativity, which set speed limit within the Universe at that of light. Or his most famous equation $E = mc^2$, which dissolved the wall between matter and energy. Finally, we have his space-time bending theory of gravitation. Taken together, Einstein’s ideas are the basis of all modern physics.

For the non-physicist, however, Einstein’s genius is a given, but largely a mystery. The man on the street knows that such things as television and the hydrogen bomb are the results of his work, but we scarcely grasps how it is so. We are, it seems, rather like the nurse at Einstein’s deathbed, who failed to grasp the great man’s final words, uttered in German. She did not speak German. Most of us do not speak physics. Instead, we sense the importance of the man indirectly and gaze like children at a parade, as his life and his genius passes before us.

**Hoyle Scoffs at “Big Bang” Universe Theory**

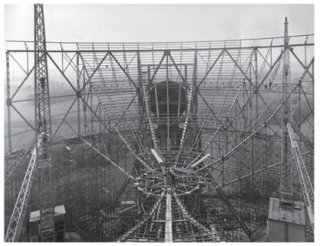
British cosmologist Fred Hoyle has thrown down the gauntlet with regards to where and when all the Universe’s elements were created. In a recent radio broadcast he panned a rival theory, championed by Ukrainian-born American physicist George Gamow, labeling it a ridiculous “big bang.”

Gamow’s Evolutionary Theory of the Universe calls on an initial stew of super-hot nuclear fusions of basic particles to create all the hydrogen in the cosmos in one explosive moment. The same blast then caused space to expand. The ongoing expansion from that “big bang” is observed by astronomers today throughout cosmos.

Hoyle is having none of it. “It is an irrational process that cannot be described in scientific terms … [nor] challenged by an appeal to observation,” he has written regarding Gamow’s theory.

For one thing, the “big bang” requires something before the explosion. No one knows what that might be. If on the other hand, the Universe is eternal and stars are always being made and forever making heavier elements, as Hoyle suggests, there is no need for an initial explosion. Recent advances in nuclear physics seem to back Hoyle’s “steady state” view, calling on the pressures and temperatures inside stars to manufacture all the heavy elements seen in the cosmos today.

**Radio ‘Ear’ on the Universe Being Built**



*Jodrell Bank’s Mark 1 radio telescope under construction.*

Construction continues for what will be Earth’s largest steerable radio antenna for listening to celestial radio broadcasts. The huge, 250-foot-wide metal dish of the Mark 1 radio telescope at Jodrell Bank in England is designed to be a fully adjustable. This will allow astronomers to explore the entire sky for radio transmissions – something they cannot do today. It will also be able to investigate the recently discovered 1420.4 Megahertz radio emissions thought to be coming from hydrogen gas at the center of the Milky Way.

The MK1 will replace the 218-foot parabolic aerial antennae, also at Jodrell Bank. That pioneering aerial uses tall poles and wire mesh to reflect and concentrate radio waves to a single point. Though the current set up allows astronomers some leeway – they can tilt the 150-foot-high central receiver pole somewhat to cover a little more sky – it relies heavily on the spinning of Earth in its orbit to change its view of the heavens.

Despite that limitation, the eight-year-old parabolic aerial has led to some important discoveries which more than made the case for building the Mark 1, according to its designer Dr. Bernard Lovell of the University of Manchester. Among the most startling and discoveries was that there are radio emissions coming from the Great Andromeda Nebula and that the brightest radio emitter in the night sky is from a little nebula in the constellation Cassiopeia.