Cosmic Times Gallery Walk

Suggested Grade Level(s): 7-12
Estimated class time: one class period

Summary

Students spend a few minutes at each Cosmic Times poster to answer an open-ended question about the information on that poster. This activity provides students an introduction to the material on the Cosmic Times posters. It may also be used to foster student discussion about a particular Cosmic Times subject.

Objectives

- Students will collaborate in teams to familiarize themselves with the big questions that faced cosmologists through the twentieth century.
- Students will recognize that science is ongoing, with technologies driving new discoveries.
- Students will discover and trace the broad history of discovery that has led scientists to their current understanding of the nature of the Universe.

National Standards

National Science Standards

- NS.5-8.7 HISTORY AND NATURE OF SCIENCE
  As a result of activities in grades 5-8, all students should develop understanding of
  - Nature of science
  - History of science
- NS.9-12.7 HISTORY AND NATURE OF SCIENCE
  As a result of activities in grades 9-12, all students should develop understanding of
  - Nature of scientific knowledge
  - Historical perspectives

National Language Arts Standards

(From the National Counsel of Teachers of English)

- NL-ENG.K-12.3 EVALUATION STRATEGIES
  Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).

Knowledge Prerequisite

The students should be able to summarize reading material.

Materials

- Cosmic Times Posters
- Cosmic Times Gallery Walk Worksheets (if using Extension)
- chart paper
- markers, pens or pencils

Preparation

Number the Cosmic Times Posters one to six from the earliest to the latest (so Cosmic Times 1919 is #1, Cosmic Times 1929 is #2, and so on). Display the posters around the classroom with ample space around each one for a small group to gather. Next to each poster place a piece of chart paper and writing implements.

Note: the articles printed on the Cosmic Times posters are aimed at high-school readers. Differentiated newsletter versions are available on the Cosmic Times website (http://cosmictimes.gsfc.nasa.gov) for readers at the 7-8 grade level (the "Early Edition"), 9-10 grade level (the "Home Edition"), and 11-12 grade level (the "Late Edition"). The posters have the Late Edition text. If another reading level is more appropriate for your classroom, you may wish to use copies of the newsletters at each station, either instead of the posters or as a supplement to the posters.

If you are asking the students to respond to the same question for all 6 of the Cosmic Times posters, then it is sufficient to write that question on the board for all students to see. However, if you would like to customize the question for each poster, then you should write each question on the blank chart paper next to each poster. Some suggested questions are given on page 5.

Procedure

I. Engagement

Ask students what they know about Big Bang theory. Was this always the leading theory for the origin of the Universe? Does our understanding of the Universe change over time? What drives scientific discovery?

Students may think that science is "done," and that scientists have all the answers. Hopefully, they recognize that science is an active discipline where new technologies are feeding new discoveries. Either way, the gallery walk will help

students see how scientific advances have helped astronomers come to their current understanding of the nature of the Universe.

II. Explanation

Explain to students that the Cosmic Times posters explore how our understanding of the Universe has changed over the past century, and they will be introduced to Cosmic Times through a "gallery walk." Point out the stations around the room, and explain that they will go from station to station in teams to answer questions about each issue of Cosmic Times. Mention that they will have a limited, but set, amount of time at each station. And be sure to indicate the order of the stations, so students know where to go next. Finally, the teams will end up back at the poster where they started. They'll report back to the class on the questions for that poster, incorporating responses from the other teams.

Count off students from one to six. Ideally you will end up with 6 teams of 4-6 students each. If you have more students, you can either put up a second set of Cosmic Times posters, or have slightly larger groups. However, if the groups are too large, it can hamper the teamwork aspect of this activity. You'll know which strategy will work best in your classroom.

Each student should be assigned a role in their team:

Leader: Keeps the team on task, encourages everyone to participate
Recorder: Writes group responses on the poster sheet
Reporter: Reports results to the class
Monitor: Acts as time keeper
Wildcard: Additional team members can be assigned to float around the group to help out anyone who needs it, or they can be assigned to help a particular other team member to double-up on certain tasks.

Each team starts at one *Cosmic Times* poster, the ones go to #1 (1919), the twos go to #2 (1929), etc.

Give students 4 minutes at their first numbered poster to respond to the question(s) at that station. Their answers should be recorded on the chart paper. Encourage the recorders to write near the top of the chart paper, to allow every group room to record their answers.

Teams are then given 3 minutes at each subsequent poster to write responses to the questions at those stations.

III. Extension (optional)

For an extended Gallery Walk, have students fill out the Gallery Walk Worksheets for each poster, found on pages 9-14. You can have each team fill

out just the worksheet for their first poster, or for all of the posters, depending on how much time you have. These worksheets can be used to reinforce the concepts on each poster, and help test for understanding.

Worksheet answers are given on pages 6-8.

IV. Evaluation

After the teams have visited each poster, they should return to their original poster. Give them a few minutes to craft a summary of the answers to the questions at their station. They should include comments made by the other teams.

Finally, give each team 2 minutes to present their summary to the class. Wrap up by discussing any questions or posters that the students had trouble with or by probing further on questions you feel your class needs to have reinforced.

Students can be evaluated by their performance in the wrap-up discussion, and/or by grading the worksheets, if the Gallery Walk Extension is used.

Resources

Bowman, Sharon L. "The Gallery Walk: An Opening, Closing, and Review Activity." http://www.bowperson.com/BOWPERSON/GalleryWalk.pdf (From Bowman's website: http://www.bowperson.com/articles.htm)

Francek, Mark. "Gallery Walk." http://serc.carleton.edu/introgeo/gallerywalk/index.html

Kagan, Spencer. Cooperative Learning Resources for Teachers. San Juan Capistrano, CA: Resources for Teachers, 1989. Print.

Suggested Questions for the Gallery Walk

For all posters:

- What big questions faced scientists in this issue of Cosmic Times?
- What advances were made due to new technologies?
- Did scientists change their view of the Universe in this issue of Cosmic Times? How? Why?

For each year:

- 1919
  - Why was 1919 such a big year for Einstein?
  - How did our view of our galaxy change? Do Shapley's observations differ from anything you currently know about our galaxy?
- 1929
  - How did our view of our galaxy change?
  - Do any of the new findings contradict previous theories? Or do they confirm them? Which ones, and how are they contradicted or confirmed?
  - Were you surprised by any of the people researching the nature of our Universe in this edition? Who and why?
- 1955
  - Why did the size of the Universe double?
  - How did the two leading theories of the origin of the Universe in this issue of *Cosmic Times* explain the expansion of the Universe?
  - What are the primary features of each of the two leading theories of the origin of the Universe in this issue of *Cosmic Times*?
- 1965
  - How did our view of the Universe change?
  - How did the cosmic microwave background discovery help astronomers decide on a leading theory of the origin of the Universe?
  - Did luck play any role in Penzias and Wilson's discovery of the cosmic microwave background? Why or why not?
  - How has our view of other galaxies changed?
- 1993
  - Why were astronomers so excited about the results from COBE? What did it tell them about the early Universe?
  - Why were the "lumps" in the cosmic microwave background so important?
  - If dark matter doesn't emit light, how do astronomers know it is there? What types of objects appear to have dark matter?
- 2006
  - How did our view of the Universe change?
  - How do we know about the presence of dark energy?
  - How did the dark energy discovery inspire new NASA satellite concepts?

Gallery Walk Extension: Worksheet Answer Key

1919 Worksheet

1. Age **Infinite** Size **300,000 light years**
2. Both Newton and Einstein's theories predicted that **gravity** would **bend** starlight as it passed by the Sun. However, Einstein predicted that the effect would be **twice** that predicted by Newton. Following careful observations during a **total** solar **eclipse**, Professor Stanley Eddington declared that the data confirmed **Einstein**'s theory.
3. **In order to see stars near the Sun, the light of the Sun needs to be blocked out – this happens during a total solar eclipse.**
4. **Einstein added the cosmological constant was to keep the Universe unchangeable. It solved the problem of requiring the Universe to be either expanding or contracting.**
5. Dr. Shapley used observations of **globular** star clusters made with the **60-** inch telescope at the **Mount Wilson** Observatory. He found a common center of **gravity** that the clusters were orbiting. He used **Cepheid** variable stars to determine distances to the star clusters. His observations showed that the center of the Milky Way is **60,000** light years from the Sun, and the Milky Way is **300,000** light years across.
6. **Answers will vary**

1929 Worksheet

1. Age **2 billion years** Size **280 million light years**
2. Dr. Hubble took photos of "**spiral** nebulae" with the **Hooker (100-inch Mount Wilson would also be acceptable)** Telescope. Those nebulae showed individual **stars**, including **Cepheid** variable **stars**. Using those variables, Hubble was able to calculate the **distance** to each nebulae. He found that Andromeda was **900,000** light years away, proving that it lies **outside** the Milky Way.
3. **Hubble's discovery settled a debate between Heber Curtis and Harlow Shapley. Curtis stated that the spiral nebulae were outside the Milky Way galaxy, while Shapley believed the evidence pointed to them being part of the Milky Way. Clearly Curtis was correct, based on Hubble's work.**
4. **spiral elliptical irregular**
5. Dr. **Slipher** had previously measured the **spectra (or redshift)** of several nebulae, and found that they were all moving **away** from us. Dr. Hubble took

this work a step further by looking at the **speed**-**distance** relationship between galaxies. His work showed that the further a nebula is from us the **faster** it is moving away. This new discovery shows that the Universe is **expanding**.

6. **Answers will vary**

1955 Worksheet

1. Age **6 billion years** Size **4 billion light years**
2. Walter Baade used the **Hooker** telescope at the Mount Wilson Observatory to take images of Andromeda. He found there were two types of stars: Type I stars are **bluer**, **brighter** and lie in **open** clusters in Andromeda's disk while Type II stars are **redder**, **fainter**, and lie in **globular** clusters. Baade deduced that there must also be two **types** of Cepheid variable stars, and they probably have different **period** -**luminosity** relationships. Correcting for this **doubles** the distances to other galaxies.
3. **The two theories for the origin of the Universe in 1955 were: the stead-state Universe and the evolutionary theory of the Universe (also known as the Big Bang). In the steady state theory, the expansion comes from the creation of new hydrogen from empty space. In the Big Bang theory, expansion comes from the initial blast that started the Universe.**
4. **Type I supernovae** **Type II supernovae**

   Difference between them: **The Type I supernovae do not have hydrogen lines in their spectra while Type II do**
5. **Answers will vary**

1965 Worksheet

1. Age **10-25 billion years** Size **25 billion light years**
2. Arno **Penzias** and Robert **Wilson** were trying to track down unwanted **microwave** signals they were detecting with the 20-foot horn-antenna in **Holmdel**, New Jersey. Even after they removed all the sources of noise they could come up with, there was radiation matching a temperature of **3.5** degrees Kelvin left over. Colleagues at **Princeton** University had the answer – the radiation was coming from the **hot**, dense ball of matter and **energy** that existed at the **beginning** of the Universe.
3. **Students can name any three of the following: Andrei Doroshkevic, Igor Novikov, Edward Ohm, Emile Le Rox, Tigran Shmaonov**
4. In NGC **3521** and NGC **972**, astronomers are finding they the amount of **light** we see doesn't match what we would expect from that much **matter**.

5. **To get the speeds of star around their center of gravity, researchers use their spectra of light. (In previous posters, this has been referred to as "redshift" or blueshift of the light, but the article here does not explicitly use those phrases. Bonus points to students who make the connection.)**
6. **Answers will vary.**

1993 Worksheet

1. Age **12-20 billion years** Size **30 billion light years**
2. The Universe started as a dense ball of **energy** that began to expand, distributing hot **radiation** and space outward in all directions. As the Universe expanded and cooled, it produced quarks and **electrons** then protons and **neutrons**. These combined to make hydrogen and **helium**. This hot gas gave off radiation in all directions that gradually cooled into **microwave** energy range, which scientists call the **cosmic microwave background** (or CMB).
3. **Without the dark matter, the gas would quickly dissipate.**
4. Inflation theory states that the **Universe** underwent a very rapid expansion in a very short amount of time causing the cosmic microwave background radiation to be **uniform** in all directions that we look.
5. **Two standard candles mentioned in the 1993 Cosmic Times: Cepheid variable stars and Type 1a supernovae. The Type 1a supernovae are better than Cepheid variables because we can see supernovae at greater distances than Cepheids.**
6. **Answers will vary**

2006 Worksheet

1. Age **13.7 billion years** Size **94 billion light years**
2. **dark energy** 73 %, **atoms** 4 %, **dark matter** 23 %
3. Dr. John C. Mather is a NASA scientist who won the Nobel Prize in **physics** for discoveries **about the cosmic microwave background**
4. C**osmic** M**icrowave** B**ackground**; Definition: **remaining light from the beginning of the Universe as seen today**
5. **Answers will vary. A couple of examples students might pull from Cosmic Times: the nature of the spiral "nebulae" or how the Universe came to be**
6. **Answers will vary**

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 1919 Cosmic Times

Fill in the following about the 1919 Cosmic Times.

1. What are the age and size of the Universe in 1919?

   Age _____ Size _____

2. Explain the landmark discovery that confirmed Einstein's Theory of General Relativity.

   Both Newton and Einstein's theories predicted that _____ would _____ starlight as it passed by the Sun. However, Einstein predicted that the effect would be _____ that predicted by Newton. Following careful observations during a _____ solar _____, Professor Stanley Eddington declared that the data confirmed _____'s theory.

3. Why did scientists need a total solar eclipse to detect the bending of starlight around the Sun?

4. Why did Einstein add the cosmological constant to his equation for General Relativity? What problem did it solve?

5. Describe Dr. Harlow Shapley's new observations of the Milky Way.

   Dr. Shapley used observations of _____star clusters made with the _____inch telescope at the _____ _____Observatory. He found a common center of _____ that the clusters were orbiting. He used _____variable stars to determine distances to the star clusters. His observations showed that the center of the Milky Way is _____light years from the Sun, and the Milky Way is _____light years across.

6. Imagine you are a journalist writing a story about the confirmation of General Relativity. What are three questions you might ask Einstein?

- _____
- _____
- _____

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 1929 Cosmic Times

Fill in the following about the 1929 Cosmic Times.

1. What are the age and size of the Universe in 1929?

   Age _____ Size _____

2. Explain what Dr. Edwin Hubble discovered about our galaxy.

   Dr. Hubble took photos of "_____ nebulae" with the _____ Telescope. Those nebulae showed individual _____, including _____ variable _____. Using those variables, Hubble was able to calculate the _____ to each nebulae. He found that Andromeda was _____ light years away, proving that it lies _____ the Milky Way.

3. Hubble's discovery settled a debate between two astronomers. Who are the astronomers, what were they debating, and who was ultimately correct?

4. What three types of galaxies did Hubble identify?

   _____ _____ _____

5. Describe Hubble's discovery about our Universe.

   Dr. _____ had previously measured the _____ of several nebulae, and found that they were all moving _____ from us. Dr. Hubble took this work a step further by looking at the _____-_____ relationship between galaxies. His work showed that the further a nebula is from us the _____ it is moving away. This new discovery shows that the Universe is _____.

6. Pretend you are on assignment for a magazine, and you need to write a profile on the scientists at Mount Wilson. What are three questions you might ask them?

- _____
- _____
- _____

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 1955 Cosmic Times

Fill in the following about the 1955 Cosmic Times.

1. What are the age and size of the Universe in 1955?

   Age _____ Size _____

2. Describe how Walter Baade determined the Universe was twice as large as previously thought.

   Walter Baade used the _____ telescope at the Mount Wilson Observatory to take images of Andromeda. He found there were two types of stars: Type I stars are _____, _____ and lie in _____ clusters in Andromeda's disk while Type II stars are _____, _____, and lie in _____ clusters. Baade deduced that there must also be two _____ of Cepheid variable stars, and they probably have different _____ -_____ relationships. Correcting for this _____ the distances to other galaxies.

3. What are the two theories for the origin of the Universe in 1955? How do they each explain the expansion of the Universe?

4. What are the two types of super-novae, and what is the major difference between them?

   Types of super-novae: _____ _____

   Difference between them: _____

5. Imagine you are writing a report on the debate between the evolutionary theory of the origin of the Universe and the steady state theory. You have interviews with Fred Hoyle and George Gamow. What are three questions you might ask them?

- _____
- _____
- _____

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 1965 Cosmic Times

Fill in the following about the 1965 Cosmic Times.

1. What are the age and size of the Universe in 1965?

   Age _____ Size _____

2. Describe the discovery of the cosmic background radiation.

   Arno _____ and Robert _____ were trying to track down unwanted _____ signals they were detecting with the 20-foot horn-antenna in _____, New Jersey. Even after they removed all the sources of noise they could come up with, there was radiation matching a temperature of _____ degrees Kelvin left over. Colleagues at _____ University had the answer – the radiation was coming from the _____, dense ball of matter and _____ that existed at the _____ of the Universe.

3. Name three scientists who missed the cosmic background radiation in their data.

   _____ _____ _____

4. How are galaxies misbehaving?

   In NGC _____ and NGC _____, astronomers are finding they the amount of _____ we see doesn't match what we would expect from that much _____.

5. How do astronomers measure the speed of stars around their center of gravity?

6. Pretend you are a journalist writing a story about the discovery of the cosmic background radiation. You have an interview with Arno Penzias and Robert Wilson. What are three questions you might ask them?

- _____
- _____
- _____

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 1993 Cosmic Times

Fill in the following about the 1993 Cosmic Times.

1. What are the age and size of the Universe in 1993?

   Age _____ Size _____

2. Explain the stages of the Big Bang.

   The Universe started as a dense ball of _____ that began to expand, distributing hot _____ and space outward in all directions. As the Universe expanded and cooled, it produced quarks and _____, then protons and _____. These combined to make hydrogen and _____. This hot gas gave off radiation in all directions that gradually cooled into _____ energy range, which scientists call the _____ _____ _____ (or CMB).

3. Dark matter is matter we cannot see, but that exerts gravity. What would happen to the gas cloud discovered by ROSAT if dark matter was not present?

4. Explain how inflation modifies the Big Bang theory.

   Inflation theory states that the _____ underwent a very rapid expansion in a very short amount of time causing the cosmic microwave background radiation to be _____ in all directions that we look.

5. What are two “standard candles” that astronomers use, as mentioned in the 1993 *Cosmic Times*? Why might the newly discovered one be better than the one discovered by Henrietta Leavitt in 1912?

6. Imagine you are a journalist writing a story about the 1993 Nobel Prize in physics. You have an interview with the recipients, Russell A. Hulse and Joseph H. Taylor. What are three questions you might ask them?

- _____
- _____
- _____

Team Members: _____ Recorder: _____

Gallery Walk Worksheet – 2006 Cosmic Times

Fill in the following about the 2006 Cosmic Times.

1. What are the age and size of the Universe in 2006?

   Age _____ Size _____

2. Using the graph, what is the composition of our Universe?

   _____ 73 %, _____ 4 %, _____ 23 %

3. Who is Dr. John C. Mather?

   Dr. John C. Mather is a NASA scientist who won the Nobel Prize in _____ for discoveries _____

   _____

4. What does the acronym CMB stand for, and what does it mean?

   C_____ M_____ B_____

   Definition:

5. The more scientists learn about dark energy, the more puzzled they become. Name a past scientific phenomenon that has been solved.

6. Pretend you are writing a story on the Adept, Snap-L, and Destiny, and you are able to interview the scientists who are developing them. What are three questions you might ask them?

- _____
- _____
- _____