

# LESSON E&S 5.4 – EVIDENCE FOR THE BIG BANG

## EVIDENCE NOTEBOOK

### KEY IDEAS

1. Temperature, energy, and matter trends:
  - a. What happens to an object's particles as the temperature rises?
  - b. What is the coldest possible temperature?
  - c. Adding energy to an element can cause the electrons to jump to a higher \_\_\_\_\_ level. When the electron falls back to its ground state it will release a \_\_\_\_\_.
  - d. Explain the trend of energy and matter when temperatures:
    - i. are at the maximum
    - ii. are at absolute zero
2. What was the temperature and density of the singularity that was the origin of the Universe?
3. Time before Planck's Time the laws of physics \_\_\_\_\_. We can not know what happened before this time.
4. The Universe expanded exponentially during the \_\_\_\_\_ Epoch.
5. The Universe \_\_\_\_\_ enough during the quark Epoch to convert energy into quarks.
6. What is plasma?
7. Further cooling allowed plasma to form during the \_\_\_\_\_ Epoch.
8. More cooling allowed atomic nuclei to first form during the \_\_\_\_\_ Epoch.
9. Why was the Universe opaque before 380,000 years of age?

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10. What does recombination mean?

11. When the Universe cooled enough, recombination first occurred during the \_\_\_\_\_ Epoch.

12. What allowed photons to escape AND cause the Universe to become transparent? (*explain in detail*)

13. What happened during the Galactic Epoch?

14. Stars began to form during the \_\_\_\_\_ Epoch.

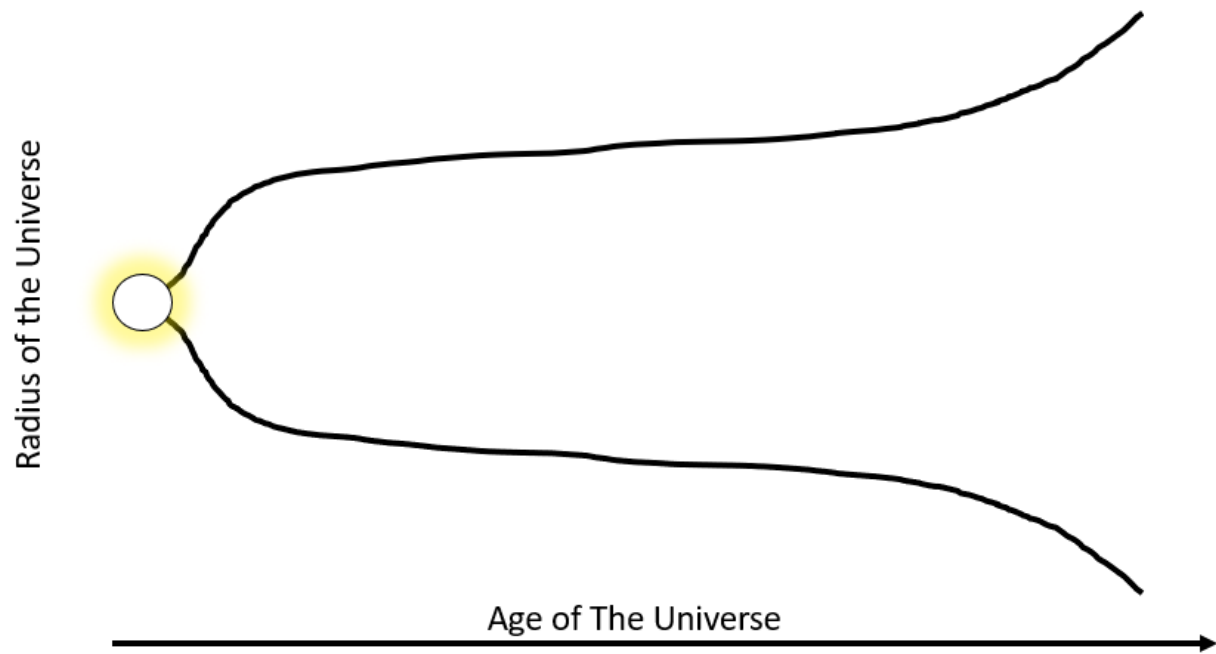
15. Hubble's Law

- a. Hubble's Law states that galaxies are moving away from each other at speeds \_\_\_\_\_ to their distances apart.
- b. Illustration what is meant by Hubble's Law:

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16. Use the diagram below to illustrate the following (*include times*):

Big Bang, Planck's Time, Inflationary Epoch, Quark Epoch, Hadron Epoch, Nuclear Epoch, Atomic Epoch, Galactic Epoch, Stellar Epoch, Present



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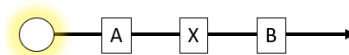
17. Explain the Raisin-Bread Model with illustrations:

18. The energy from the Big Bang does not explain how the universe is expanding faster than it was before. The unknown force that causes this is called \_\_\_\_\_.

19. Illustrate and explain the four theories regarding the future for our Universe:

**CHECKPOINTS**

20. The sketch below presents a different model of universe expansion, one in which expansion is in one direction from a single point. If X were Earth, how would a spectrum from galaxy A most likely differ from that of galaxy B?



- a. Spectra A and B would not differ.
  - b. Spectrum A would show a redshift and spectrum B a blueshift.
  - c. Spectrum A would show a redshift, and spectrum B would not be shifted.
  - d. Spectrum A would show a blueshift and spectrum B a redshift.
21. Put the following terms associated with the evolution of the universe in order from earliest to most recent.

Transparent, Stable nuclei, Plasma, Complex molecules, Hydrogen atom

22. For each statement (a) through (d) below, identify whether it describes a process or characteristic associated with *hydrogen*, *helium*, or *both hydrogen and helium*.
- a. This formed when cooling temperatures allowed collisions to form stable nuclei.  
\_\_\_\_\_
  - b. This Accounts for approximately 25% of the Universe’s mass. \_\_\_\_\_
  - c. The amount of this would be different had our universe’s rate of expansion been different. \_\_\_\_\_
  - d. Isotopes of this include deuterium and tritium. \_\_\_\_\_
23. Which of the following are true regarding the cosmic microwave background? *Choose all correct answers.*
- a. Radiation released when the universe became transparent is an indication of the temperature at the time.
  - b. The expansion of the universe caused changes in visible-light frequencies.
  - c. Detection of CMB from every direction in space indicates the universe is expanding in all directions.
  - d. If the universe were not expanding, we would observe the Universe’s earliest generated light as visible light.

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24. The first hydrogen and helium formed through the fusion of subatomic particles in the early universe. How do the relative abundances of hydrogen and helium in the present-day universe provide evidence for the big bang theory?

25. Observations of galaxy motion indicate that the universe is expanding in all directions. Do scientists infer, therefore, that the Milky Way's position in space is static? Choose the best answer.

- a. No. The ratio of H:He indicates the rate of current expansion includes all objects in the universe.
- b. Yes. The fact that CMB is coming from all directions as well further supports this conclusion.
- c. No. If we were in another galaxy, the Milky Way would be travelling away from us.
- d. Yes. If the Milky Way were moving too, we would see a different pattern of galaxy motion around us.

26. Observations of spectra from the Andromeda galaxy show that it is moving toward the Milky Way galaxy. Scientists estimate that the galaxies will merge in about 4 billion years. Is this evidence against the big bang theory? Explain your answer

27. Telescopes such as the Hubble Space Telescope allow us to see back in time. Use an example to explain what this means and how it is possible.

28. Based on what you have learned so far, do you think it would be possible to detect light and create images of what the universe looked like in the seconds or minutes after the big bang? Explain your reasoning.
29. What is important about Hubble's discovery that there is a red shift in the spectra of galaxies?
- It proves the Big Bang theory.
  - It suggests the existence of black holes.
  - It suggests that the universe is expanding.
  - It suggests that the universe is contracting.
30. How does the Cosmic Microwave Background Radiation (CMBR) mark an important milestone in the early history of the universe?
- It marks time when the universe transitioned from opaque to transparent.
  - The CMBR originated from the initial force that triggered the Big Bang. It is the remnant energy from the previous universe.
  - The CMBR originated when the first massive stars in the universe began exploding as supernovas shortly after the Big Bang.
  - The CMBR originated as the first microwave radiation. It marks the time the universe first became energetic enough to produce microwaves.
31. When did the universe begin?
- 1 billion years ago
  - 10 million years ago
  - 14 billion years ago
  - 50 billion years ago

32. During the first few minutes after the Big Bang, the universe was opaque. Light could not go through it. Why?
- All the photons were being absorbed.
  - There was nothing to produce photons.
  - The photons were attracted to other particles.
  - The mix of particles was so dense that photons could not get through.
33. What determined the temperature, density, and ratio of hydrogen to helium of the universe soon after the Big Bang?
- the rate at which the universe expanded
  - the rate of nuclear fusion in the first stars
  - the density of the material the universe was expanding into
  - the timing of the transition from an opaque to a transparent universe
34. A classmate named Brandon is arguing that if the universe had expanded more slowly than it did, the transition from an opaque to a transparent universe would have happened sooner than it actually did. How would you explain to Brandon, using the formation of the first elements in the universe, that he is wrong?
35. Redshift of light from many galaxies was first observed in the 1920s. What was the significance of that?