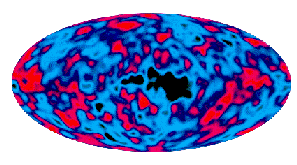
**The Expanding Universe Overview**

This activity is designed to help students gain a deeper understanding of cosmology.  Students develop authentic models and gather evidence supporting the Big Bang theory.

Learner Outcomes

By completing this activity, the learner will:

* Illustrate the expansion of the Universe with a model.
* explain and apply (redshift velocity) = (distance)\*( Hubble constant).
* give supporting evidence for the Big Bang theory.

**Concept Introduction**

1. In this activity, you are going to create a model of the expanding Universe.  You will need one balloon, a paper strip for conducting measurements, a copy of this page, and a marker, a ruler, and a timer.

2. Partially inflate the balloon to the size of your fist. Bend the end of the balloon down so that no air escapes.

3. Use the markers to make 11 dots on the top portion of the balloon and number them. **Measure the initial distance each dot is FROM DOT 1 (us) and record in the data table under initial distance.**

4. Inflate balloon slowly **while timing** to about **four times its original size**.

5. Measure and record the distance between dot number *one* (your "home" dot) and neighboring dots with the paper strip and then line up on a ruler. Be careful not to indent the balloon by pressing on it. **Record in the data table under Expanded and record your time.**

7. Turn your balloon in to Mr. Mega and get your paper stamped. **Papers not stamped in the allotted time will result in a 20% deduction.**

8. Answer the summary questions below.

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| Partially Expanded | | | Expanded | | | Velocity v = change / time | |  | | |  | |
| Dot | Initial Distance from Dot #1 | | Dot | distance from Dot #1 | Change from Before to After | Dot | velocity from Dot #1 | |  |  | |
|  | |  |  |  |  |  | |
| 2 | 2 | | 2 | 2 | 2 | 2 |  | |  |  | |
| 3 | 2 | | 3 | 2 | 2 | 3 |  | |  |  | |
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| 9 | 2 | | 9 | 2 | 2 | 9 |  | |  |  | |
| 10 | 2 | | 10 | 2 | 2 | 10 |  | |  |  | |
| 11 | 2 | | 11 | 2 | 2 | 11 |  | |  |  | |
|  | | **Time \_\_\_\_\_\_\_\_\_\_\_\_\_\_**  **Graph Your Data for galaxies 2-11(Initial Distance and Change from Before and After)**  **Graph Your Data for galaxies 2-11(Initial Distance and velocity)** | | | | | | | | | | |

***Summary Questions***

1. What happens to the distances between the galaxies?

2. Do the distances between the galaxies change equally?

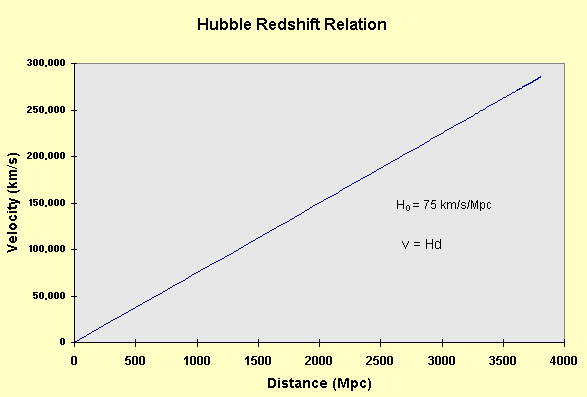
3. Interpret Your Graphs; What do they show?

4. If the dots represent galaxies, do they get larger as the balloon expands?

Why do you think this is or is not so?

5. What relationship exists between the speed of the galaxies moving apart and their initial distance from one another?

**Exploration**

Using the graph below, have students explore the various axes and look for clues to what the graph might mean.  In particular, the horizontal axis is distance from our galaxy, the Milky Way, to other galaxies.  The vertical axis is recessional velocity.  Note how there is a clear proportionality between distance and recessional velocity.  This proportionality is known as the Hubble Law.  The slope of this line, with dimensions of velocity over distance, is called the Hubble Constant.

What does this graph show?

https://btc.montana.edu/ceres/html/Universe/images/lessondebrief.JPG

[Cosmology](http://www.nap.edu/readingroom/books/cosmology/) is the search for origins.  It seems as if everyone wants to know how the Universe began.  The Big Bang theory is the result of several important observations.  In 1927, Edwin Hubble first observed that light from distant galaxies is red shifted and that galaxies are moving farther and farther away from us.  Second, he determined that the farther away a galaxy is from us, the faster it is receding from us.  If the Universe is expanding, then one can assume that the galaxies that compose our Universe were once much closer together than they are now.  By simply measuring how far apart galaxies are and how fast they are moving, we determine the [Hubble Constant](https://btc.montana.edu/ceres/html/Universe/hnought.htm) (estimates range from 50 to 100 km/s per kiloparsec).  It is very easy to determine the recessional velocity of galaxies; on the other hand, their current positions are difficult to measure.  Distances to galaxies are typically measured by finding Cepheid variable stars or supernovae with known brightness.

If we run the expansion process backward, we get two results.  The first is that it probably took approximately 15 billion years for the Universe to grow to its present size.  Second, the Universe must have begun its expansion in an awesome event that astronomers call the Big Bang.

The Hubble Law states that the recessional velocity of a distant galaxy is proportional to its distance from us.  The recessional velocity of a galaxy is measured by examining the Doppler shift of lines in the spectrum of light from the galaxy.  The distance to the galaxy is more difficult to measure, but can be estimated from its apparent angular size or by the brightness of objects in it.

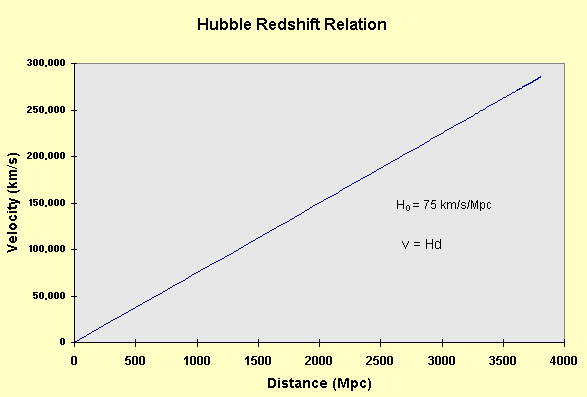
1. How are distances to galaxies found?

2. Explain Hubble’s Law.

3. How does Hubble’s Law support (provide evidence) for the Big Bang?

4. Explain Hubble’s Constant.

What does the unit km/s /Mpc mean?

5. According to the graph, as the galaxies get farther away, what happens to their recessional velocities?

6. Use what you did with the balloon to explain your answer

to number 5.

7. If you were to continue to blow up the balloon and it was a balloon

that would not pop until it got “extremely” big, what would you notice

happen to the galaxies themselves?

What would happen to individual stars eventually? How do you think this relates to what dark energy could ultimately cause to happen in the universe?

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