Introduction to the Universe
The universe began 13 billion years ago
The universe is expanding in all directions
Lecture Tutorial: The Big Bang
How do we *know* the universe is expanding?
The Doppler Shift: A change in the wavelength of a wave due to motion
Light is also a wave
If you increase the wavelength of light, the light becomes:

(A) Redder
(B) Bluer
(C) Stays the same in color
You are in a spaceship flying away from a star. Compared to the light you would see if you were stationary, the light from that star will look:

(A) Redder

(B) Bluer

(C) The same in color
You are in a spaceship flying towards a galaxy. Compared to the light you would see if you were stationary, the light from that galaxy will look:

(A) Redder
(B) Bluer
(C) The same in color
Which of the following bands of the electromagnetic spectrum has photons with the largest wavelength?

A) X-Rays (or Gamma-Rays)
B) Visible (or UV or IR)
C) Microwave (or Radio)
D) Choices A, B, & C all have the same wavelength
You are in a spaceship flying away from a star. When you were stationary, the starlight was in the visible light part of the electromagnetic spectrum. What part of the electromagnetic spectrum might the starlight appear to be in now?

(A) Gamma ray  
(B) X ray  
(C) Ultraviolet  
(D) Infrared
There are hundreds of billions of galaxies in the universe

The Hubble “deep field”
Galaxies come in many shapes and sizes. Each galaxy is made of hundreds of billions of stars.
They are shaped by collisions
The farthest known galaxy is 13 billion light years away. So, the light we see left this galaxy 13 billion years ago.
A light year is the *distance* travelled by light in one year.
The galaxy *closest* to the Milky Way is the Andromeda Galaxy. It is so far away, that the light that reaches us left the galaxy 2.9 MILLION years ago.
Lecture Tutorial: Looking at Distant Objects
Our galaxy is called the Milky Way.

It is a spiral galaxy.

If we could see it from afar, it would look something like this:

The sun
Because we live inside of the Milky Way, it looks like this instead:
The Milky Way consists of hundreds of billions of stars and has a black hole at its center.
Our sun lies $10^{11}$ meters away from us.
(this is 8 light minutes)
Our sun lies $10^{11}$ meters away from us.
(this is 8 light minutes)

8 light minutes is the ______________ that light travels in a time of ______________
We live in the solar system.
Here is a diagram of the planetary orbits.
What might the solar system actually look like from afar?
What might the solar system actually look like from afar?

This is a photo of Alpha Centauri
What does the Earth look like from afar?

A solar system portrait from the Voyager spacecraft.
What does the Earth look like from afar?

A portrait of the Earth from the Cassini spacecraft.
Lecture Tutorial: Milky Way Scales
Activity: What is your cosmic address?

Street number/PO Box, City, State, Country

P.O. Box 3129, Sells, AZ, USA
In the organizational diagram below, the term **Earth** would most appropriately fit in the area labeled...?
In the organizational diagram below, the term **Saturn** would most appropriately fit in the area labeled…? 

- **A** Solar System 
- **B** Milky Way 
- **C** Universe
In the organizational diagram below, the star Alpha Centauri would most appropriately fit in the area labeled...?

(A) Solar System

(B) Milky Way

(C) Universe
In the organizational diagram below, the term **Andromeda Galaxy** would most appropriately fit in the area labeled...?