

Discovery Year	Redshift Z	Age (millions of yrs)	Object Name or Catalog Number	Type
1930	Infinity	13,700	Big Bang	Creation
2011	10	13,200	UDFj-39546284	Galaxy fragment
2010	8.6	13,100	UDFy-38135539	Galaxy fragment
2009	8.2	13,070	GRB090423	Gamma ray burst
2008	7.6	13,000	A1689-zD1	Starburst Galaxy
2006	6.9	12,880	IOK-1	Galaxy
2007	6.4	12,700	CFHQS J2329-0301	Black Hole/Quasar
2011	5.3	12,600	COSMOS-AzTEC3	Galaxy Cluster

The universe was born 13.7 billion years ago in the ‘Big Bang’ and since then has been expanding to its present, enormous size. By using sensitive telescopes such as NASA’s Hubble Space Telescope, astronomers can study the images of ancient galaxies, whose light has been traveling towards Earth for billions of years. For the most distant objects, their light has been traveling towards Earth for over 10 billion years, allowing astronomers to see what these distant galaxies looked like 10 billion years ago. The ‘race’ has been on to detect the most ancient images of galaxies so that astronomers can learn about the events that created the first galaxies and stars in the universe. The table above shows the light travel times for various known objects that have been identified by 2011. For the problems below, assume that these objects are common examples of their types at their estimated ages.

Problem 1 – Create a timeline that shows the age of each object since the Big Bang.

Problem 2 – How many million years after the Big Bang did the first galaxy fragments begin to form?

Problem 3 – About how many million years after the formation of the first galaxy fragments did the formation of the first galaxies begin?

Problem 4 – The quasar CFHQS J2329-0301 contains a black hole with a mass estimated to be 500 million times the mass of our sun. If this ‘supermassive’ black hole began to form when the first galaxy fragments appeared, about how many years did it take to form this black hole?

Problem 5 – About how many years elapsed between the appearance of the first galaxy fragments, and the first cluster of galaxies in the universe?

Problem 6 – In your timeline, what is the largest gap in time for which we, as yet, have not observed any candidate objects?

**For more information online:
Cosmic Background Radiation**

<http://wmap.gsfc.nasa.gov/>

UDFj-39546284

http://www.nasa.gov/mission_pages/hubble/science/farthest-galaxy.html

UDFy-38135539

<http://www.hubblephotoprints.com/blog/hubble-telescope-reveals-the-most-distant-galaxy-ever-found/>

GRB090423

http://science.nasa.gov/science-news/science-at-nasa/2009/28apr_qrbsmash/

A1689-zD1

<http://www.spacetelescope.org/news/heic0805/>

IOK-1

<http://www.physorg.com/news176737523.html>

CFHQS J2329-0301

<http://www.gemini.edu/index.php?q=node/254>

COSMOS-AzTEC3

http://www.nasa.gov/mission_pages/spitzer/news/spitzercluster20110112.html

Problem 1 – Create a timeline that shows the age of each object since the Big Bang. Answer:

Age (millions of yrs)	Years since the Big Bang	Object Type
13,700	0	Creation of time, space and matter
13,200	500 million	Galaxy fragments begin to form
13,100	600 million	Galaxy fragments still present
13,070	630 million	Gamma ray burst appears - supernovae
13,000	700 million	Starburst Galaxy and intense star formation
12,880	820 million	Galaxies begin to form
12,700	1 billion	Supermassive black holes appear
12,600	1.1 billion	Galaxy Clusters begin to form

Note: The Object Type can be used to indicate what kinds of events are taking place. Shown above is an example.

Problem 2 – How many million years after the Big Bang did the first galaxy fragments begin to form? Answer: that would be the time between the Big Bang (13.7 billion years ago) and UDFj-39546284 (13.2 billion years ago) or **500 million years**.

Problem 3 – About how many million years after the formation of the first galaxy fragments did the formation of the first galaxies begin? Answer: That would be the time between 13.2 billion years ago when we are seeing one of the first galaxies, UDFj-39546284, and the appearance of IOK-1 at 12.880 billion years ago or about **820 million years** after we first start seeing fragments of galaxies.

Problem 4 – The quasar CFHQS J2329-0301 contains a black hole with a mass estimated to be 500 million times the mass of our sun. If this ‘supermassive’ black hole began to form when the first galaxy fragments appeared, about how many years did it take to form this black hole? Answer: Galaxy fragments first appeared about 13.2 billion years ago (UDFj-39546284) and the quasar image is 12.7 billion years old, so the difference in time is about **1 billion years**.

Problem 5 – About how many millions of years elapsed between the appearance of the first galaxy fragments, and the first cluster of galaxies in the universe? Answer: Fragments formed about 13.2 billion years ago; clusters appeared about 12.6 billion years ago, so it took **about 600 million years**.

Problem 6 – In your timeline, what is the largest gap in time for which we, as yet, have not observed any candidate objects? Answer: **Between the Big Bang (13.7 billion years ago) and the appearance of the first galaxy fragments (13.2 billion years ago) or 500 million years**.