Our Place in the Universe

What is the cosmological setting for humanity in the universe?

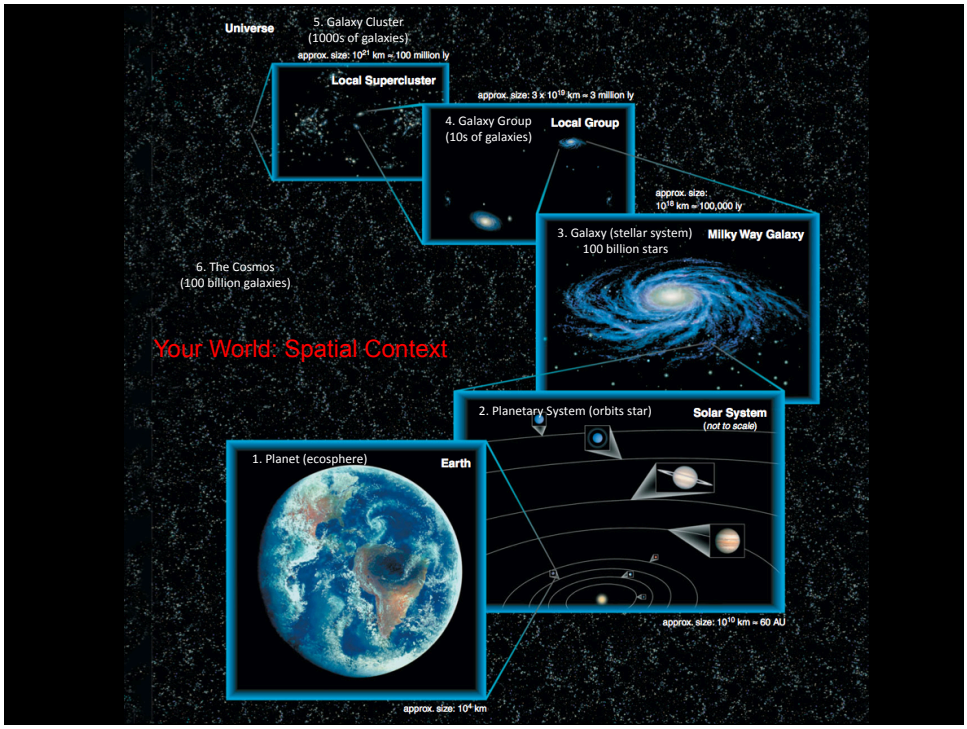
- Where (and when) do we fit in it?
- What are the main structures and how are they related?
- What are their relative sizes and locations?

Let's define some **distances**:

Astronomical Unit (AU) = radius of earth's orbit
= 93 million miles (93,000,000 mi)
= 150 million kilometers (150,000,000 km)

Lightyear (lyr) = distance light travels in 1 year
= 6 trillion miles (6,000,000,000,000 mi)
= 10 trillion kilometers (10,000,000,000,000 km)

The speed of light is 186,000 mi/sec or 300,000 km/s
There are 31.5 million seconds in 1 year
A lightyear is 9.46×10^{13} km = 94,600,000,000,000 km
5.86×10^{13} mi = 58,600,000,000,000 mi



Distance measured in "light time"

speed of light = 300,000 km/s = 186,000 miles/sec

Sun-Earth distance (1 AU)…	8 light minutes
Solar System diameter…….	22 light hours
Nearest Star……	4 light years
Galaxy diameter……..	100,000 light years
Local Group diameter……	1,000,000 light years
Galaxy Cluster diameter……	100,000,000 light years
Size of Universe……..	13,600,000,000 light years

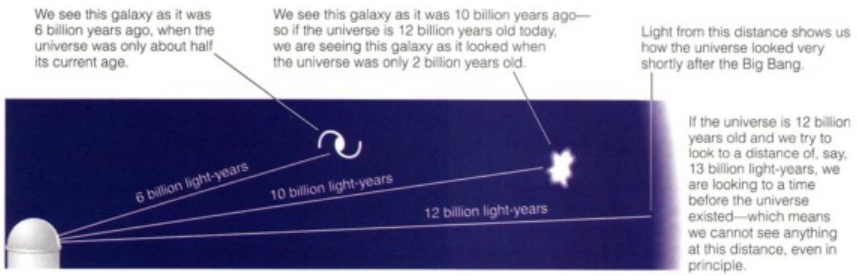
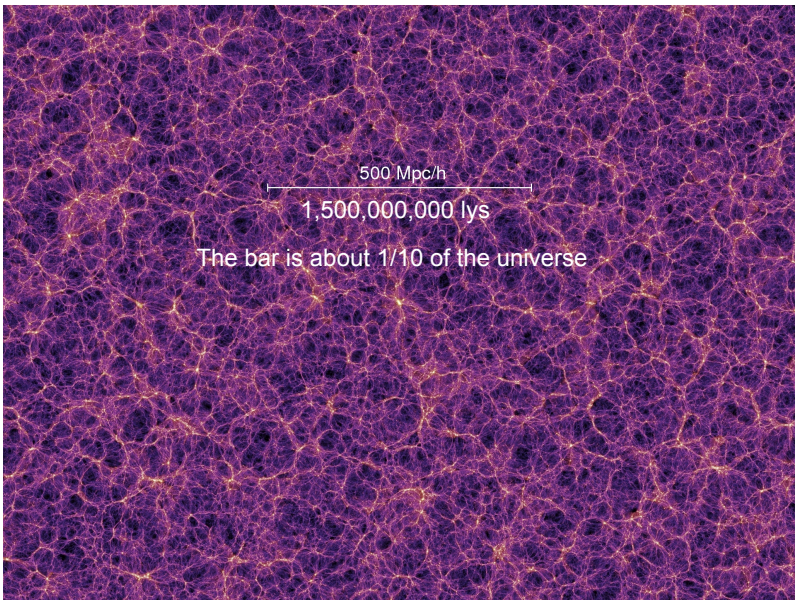
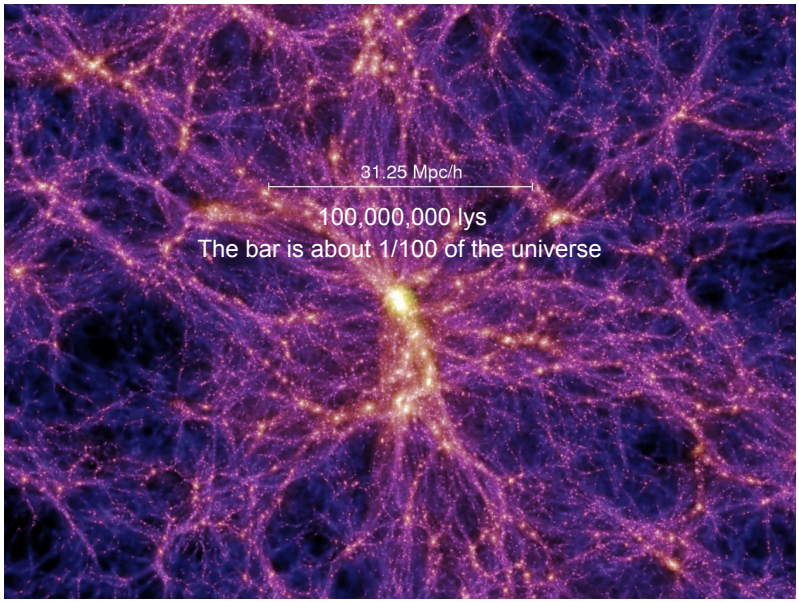


FIGURE 1.13 Because light travels at a finite speed, looking farther away in space means looking further back in time. This fact limits the extent of our observable universe. This figure assumes the universe is 12 billion years old; its actual age may be anywhere between about 12 and 15 billion years.

Representative Slice of the Universe

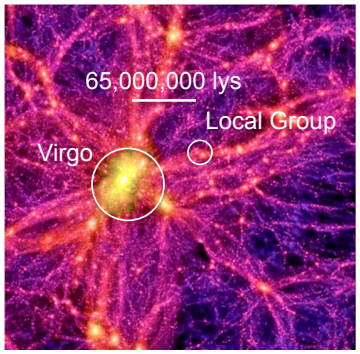


100,000,000 lys: A Cluster of Galaxies



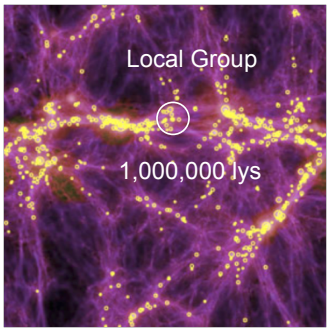
The Local Group is in the "suburbs" of the Virgo Cluster

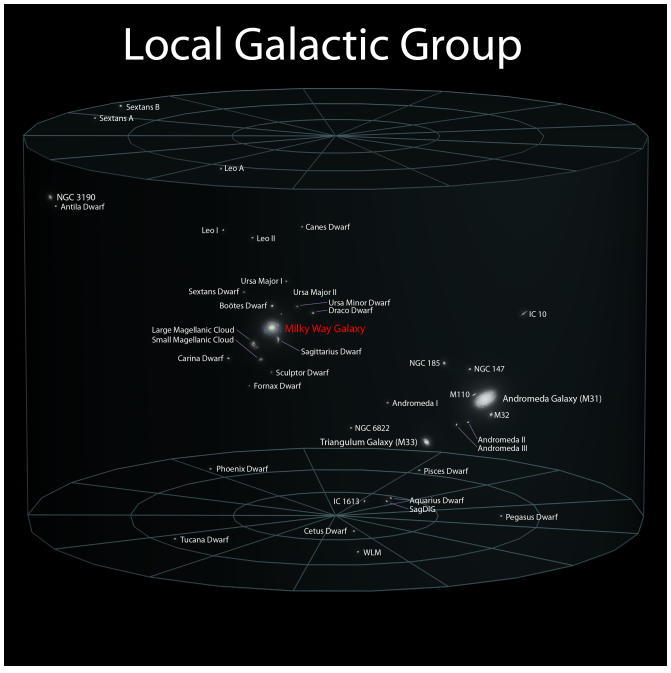
– about 65 million light years away from the center

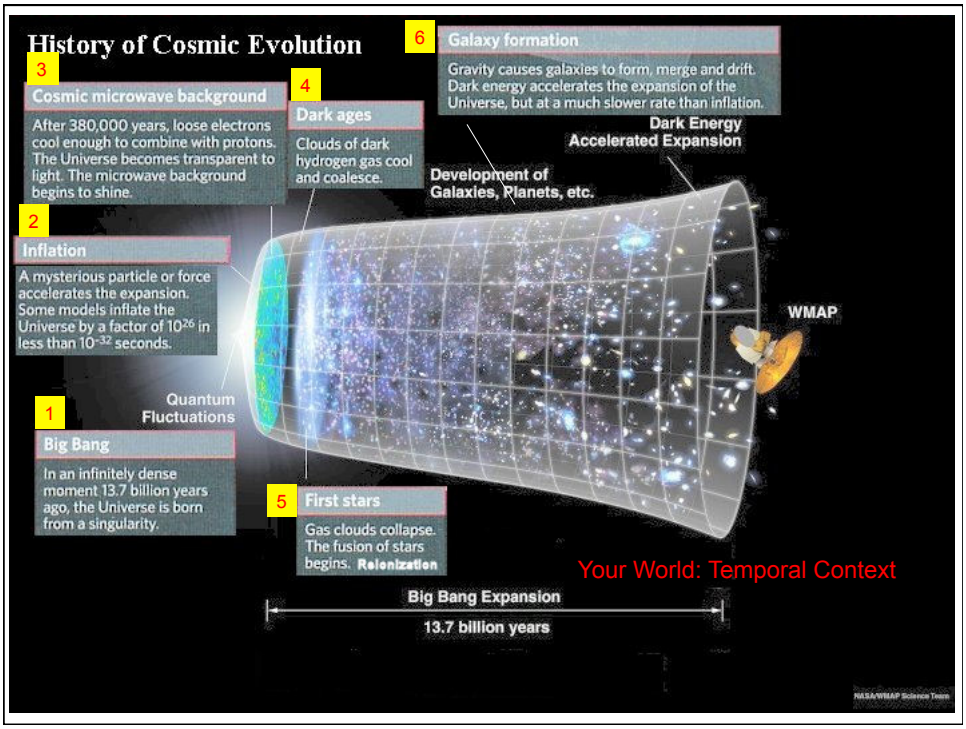


Our galaxy, The Milky Way resides in the Local Group

– Milky Way, 100,000 lys across, is about 1/10th the size of the Local Group







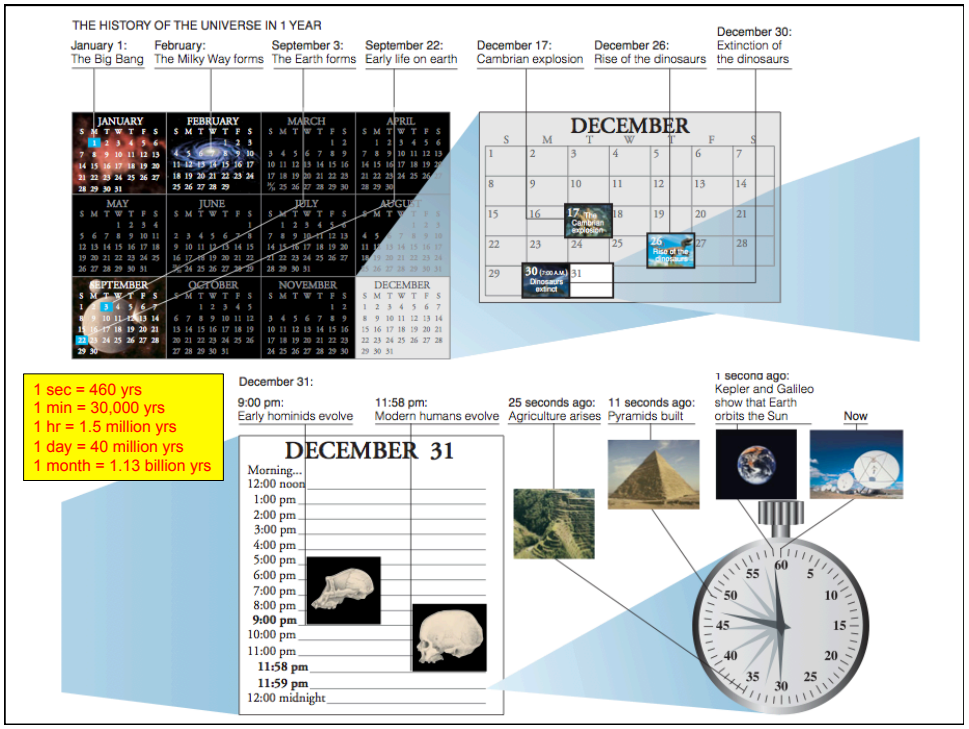
Video of the evolution of the universe in a representative 35 million light year cube (35 times the size of the Local Group; about 1/3 the size of a Galaxy Cluster (so a pretty small cube; about 1/400 of the universe itself)

This is a computer simulation; it includes

- Gravity of dark matter and regular matter
- Star formation and death, process of gas into stars and stars back into gas
- Build up of chemical elements
- Expansion of the universe based upon General Relativity

Click on the link below:

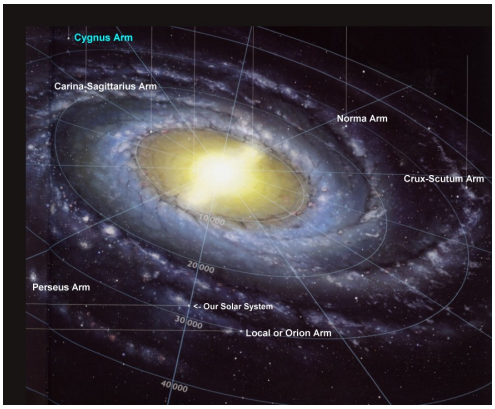
https://www.youtube.com/watch?v=jx_64y7gA_k&spfreload=10
VIDEO: Evolution of the Universe (Illustris Simulations) 2:34

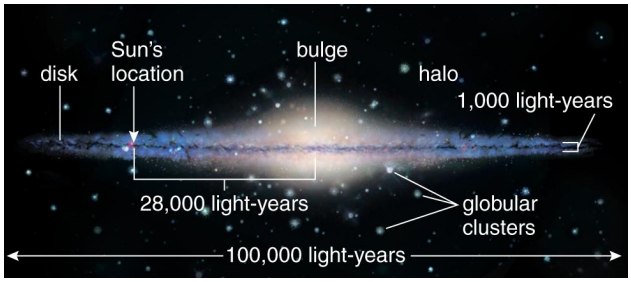


Anatomy of our Home Galaxy- Our Place in It

It take about 250,000,000 years for one rotation

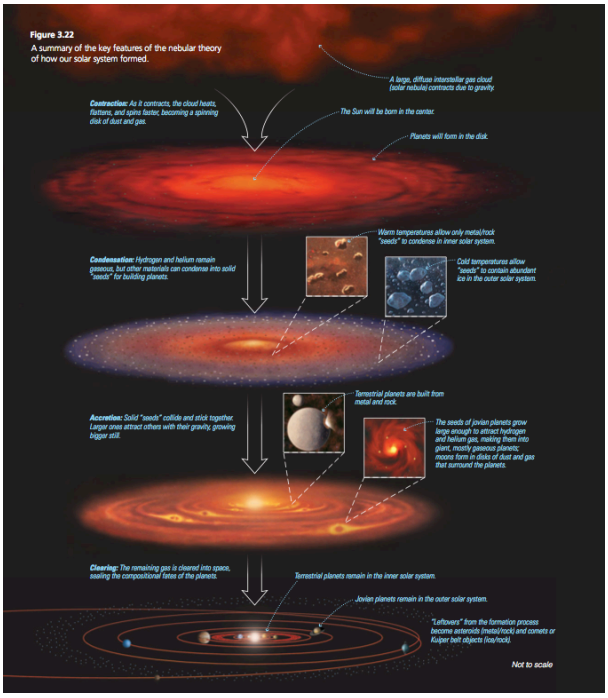
The sun has orbited the Milky Way about 20 times since its birth



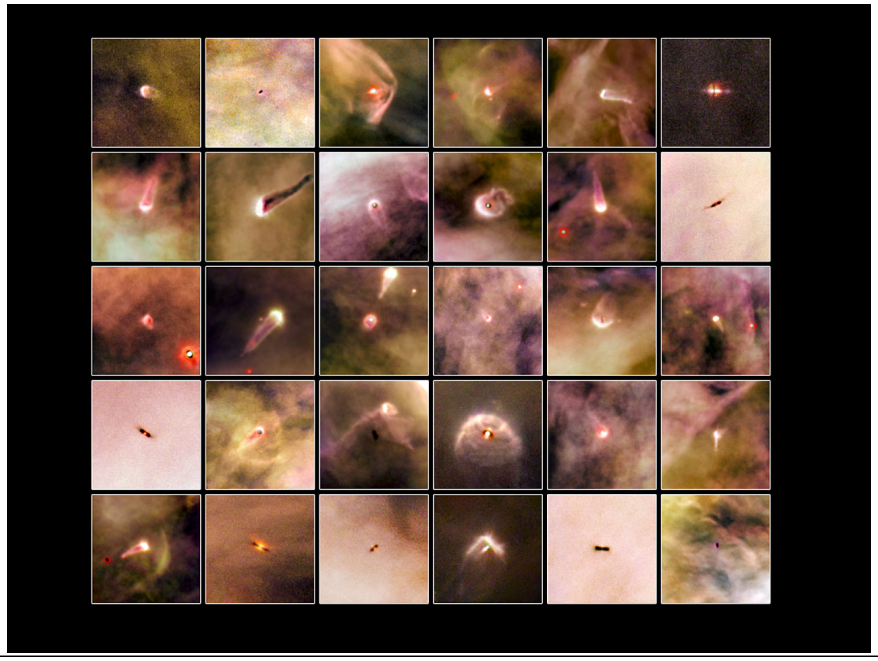


Galaxies are ecosystems in which stars and planets form gas (and eventually die and turn back into gas) It's a cycle.

Formation Scenario

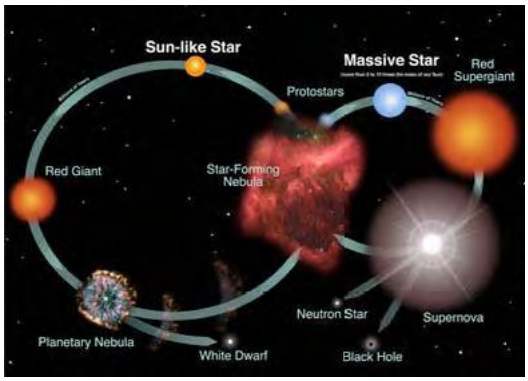


Hubble Space Telescope Images of Forming Star and Their Planets



The Cycle of Stars

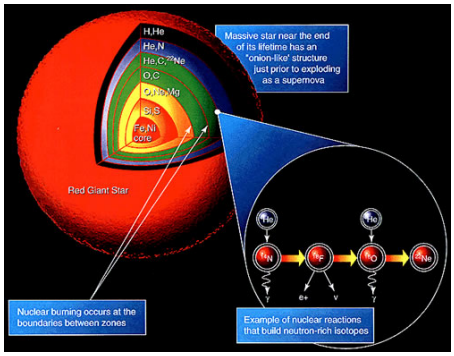
During middle-age, all stars use nuclear fusion to power themselves, converting hydrogen into helium. Massive stars are very efficient at this, and also convert helium into carbon, and carbon into magnesium, etc., building up all the elements of the periodic table.



Sun-like star	Massive star
Nebula/Formation	Nebular/Formation
Mid-Age	Mid-Age
Red Giant	Super Giant
Planetary Nebula	Supernova
White Dwarf	Neutron Star or Black Hole

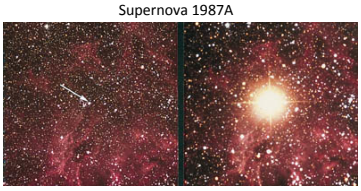
It's the supernovae form massive stars that seed the next generation of stars…

The Cycle of Stars



After building elements up to iron, BANG! These elements then are distributed into the local area of the galaxy where the star exploded. -> new stars form, planets form with these new elements…. Sun/Earth!!

Supernova 1987A



Supernova 2011fe

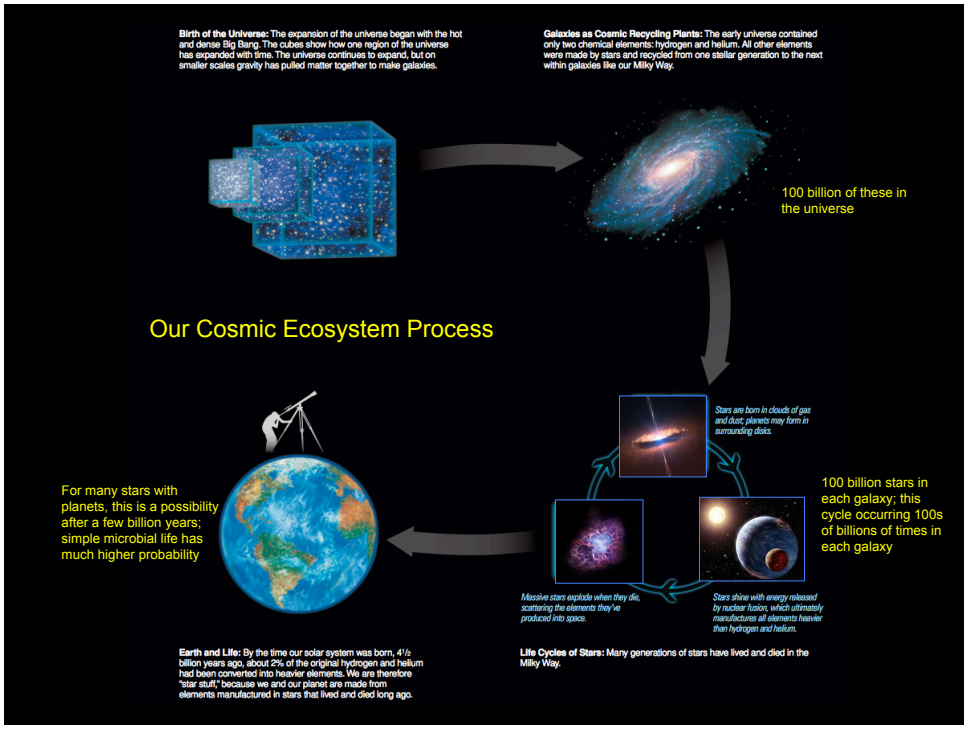
The sun is a 3rd generation star in the Milky Way. About 6 billion years ago a massive star exploded as a supernova in our region of the Milky Way, distributing its heavy elements into the area. The shock wave compressed other gas and a nebula was formed from which the Sun and solar system formed. The carbon, oxygen, and nitrogen in the Sun, on the Earth, and in your bodies came from the supernova that seeded our region of space.

YOU ARE STAR STUFF – you elements were once in the core of a star

Just released (January 2015) *Hubble Space Telescope* images of the deepest ever pictures resolving the individual stars in the galaxy of Andromeda.

Another Galaxy has NEVER been seen like this before.

https://www.youtube.com/watch?v=udAL48P5NJU
VIDEO: Gigapixels of Andromeda 3.28


Birth of the Universe: The expansion of the universe began with the hot and dense Big Bang. The cubes show how one region of the universe has expanded with time. The universe continues to expand, but on smaller scales gravity has pulled matter together to make galaxies.
Galaxies as Cosmic Recycling Plants: The early universe contained only two chemical elements: hydrogen and helium. All other elements were made by stars and recycled from one stellar generation to the next within galaxies like our Milky Way.
100 billion of these in the universe
Our Cosmic Ecosystem Process
Stars are born in clouds of gas and dust; planets may form in surrounding disks.
100 billion stars in each galaxy; this cycle occurring 100s of billions of times in each galaxy
Stars shine with energy released by nuclear fusion, which ultimately manufactures all elements heavier than hydrogen and helium.
Massive stars explode when they die, scattering the elements they've produced into space.
For many stars with planets, this is a possibility after a few billion years; simple microbial life has much higher probability
Earth and Life: By the time our solar system was born, 4½ billion years ago, about 2% of the original hydrogen and helium had been converted into heavier elements. We are therefore "star stuff," because we and our planet are made from elements manufactured in stars that lived and died long ago.
Life Cycles of Stars: Many generations of stars have lived and died in the Milky Way.