The Universal context of life

Questions ...

- How do the age and size of the Universe affect the search for life in the Universe?
- Where did the ingredients for life on Earth come from?
  - Are they found elsewhere in the Universe?
- If our Solar System had formed much earlier, could the Earth have formed? Could life have appeared?
- Where in the Universe are we capable of searching for life?

Questions ...

- How old is the Universe?
- How big is the Universe?
- Where did all this "stuff" come from?

Universe

approx. size: 10^{21} km

Local Supercluster

approx. size: 3×10^{19} km

Local Group

approx. size: 10^{18} km

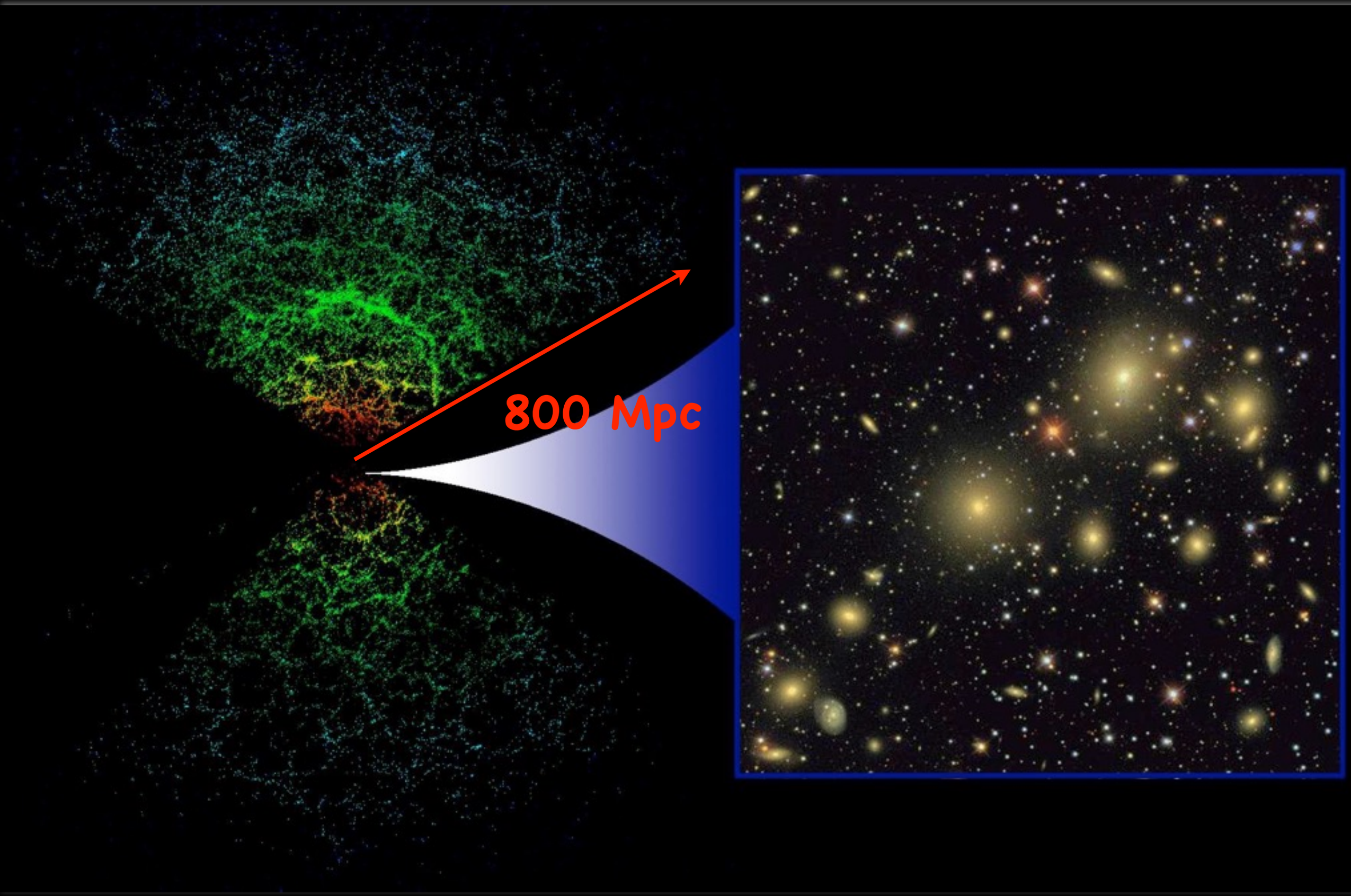
Milky Way Galaxy

Earth

Solar System
(not to scale)

approx. size: 10^{10} km

approx. size: 10^{4} km


800 Mpc

How old is the Universe?

- The Universe of galaxies appears to be expanding in all directions.
- The expansion is described mathematically by Hubble's Law
- velocity = H x distance
- H is Hubble's constant.
- If we calculate 1/H, this is the time since the galaxies were all collected together at one point - the Big Bang!
- We can measure Hubble's constant from surveys such as the Sloan Digital Sky Survey (SDSS).
- The answer we get for the age of the Universe is close to 13.7 Billion years.

The history of the Universe

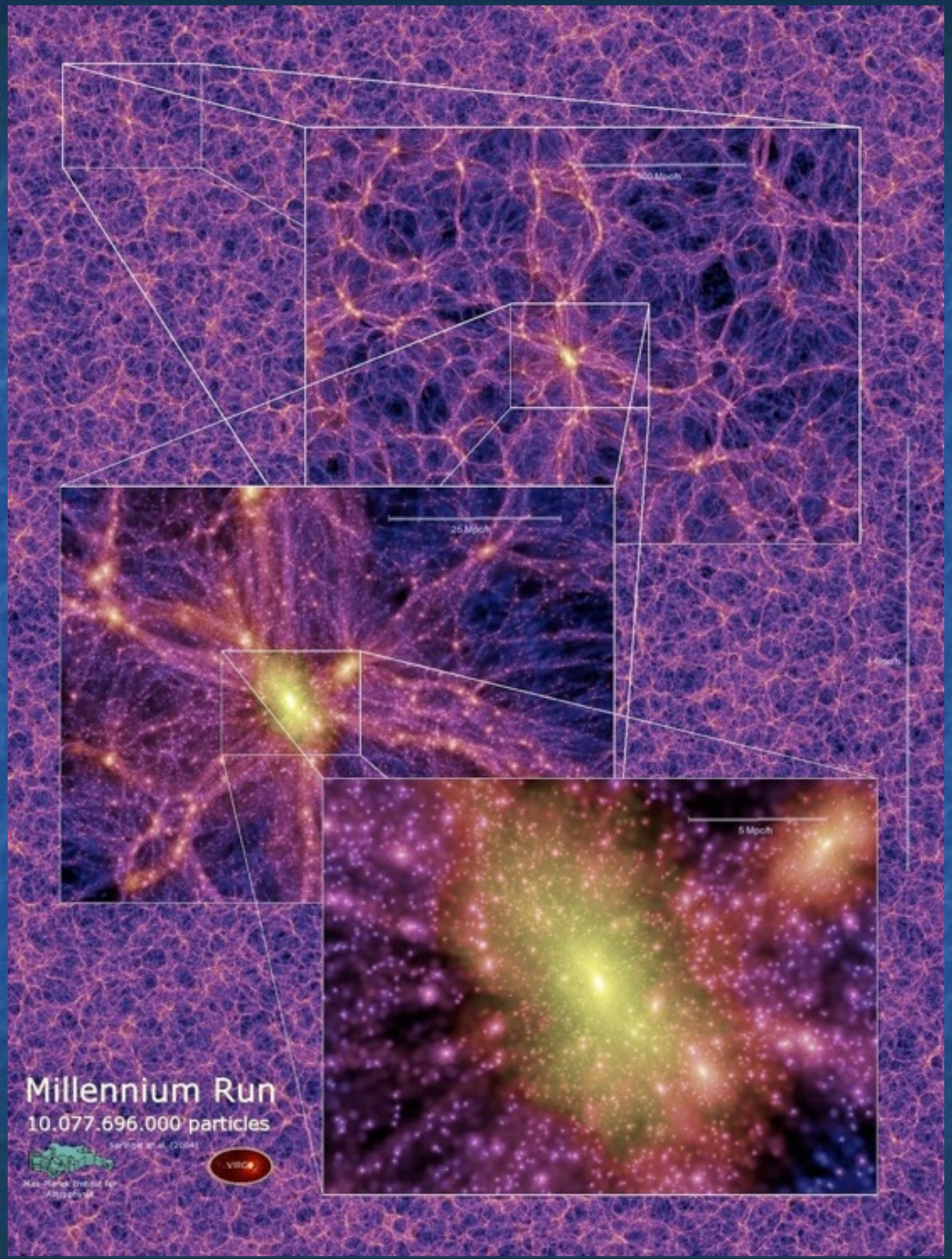
January	February	March	April	May	June	July	August	September	October	November
New Year's Day: The Big Bang		Mily Way forms					Sun and planets form	Oldest known life.(single celled).		First multi-celluar organisms

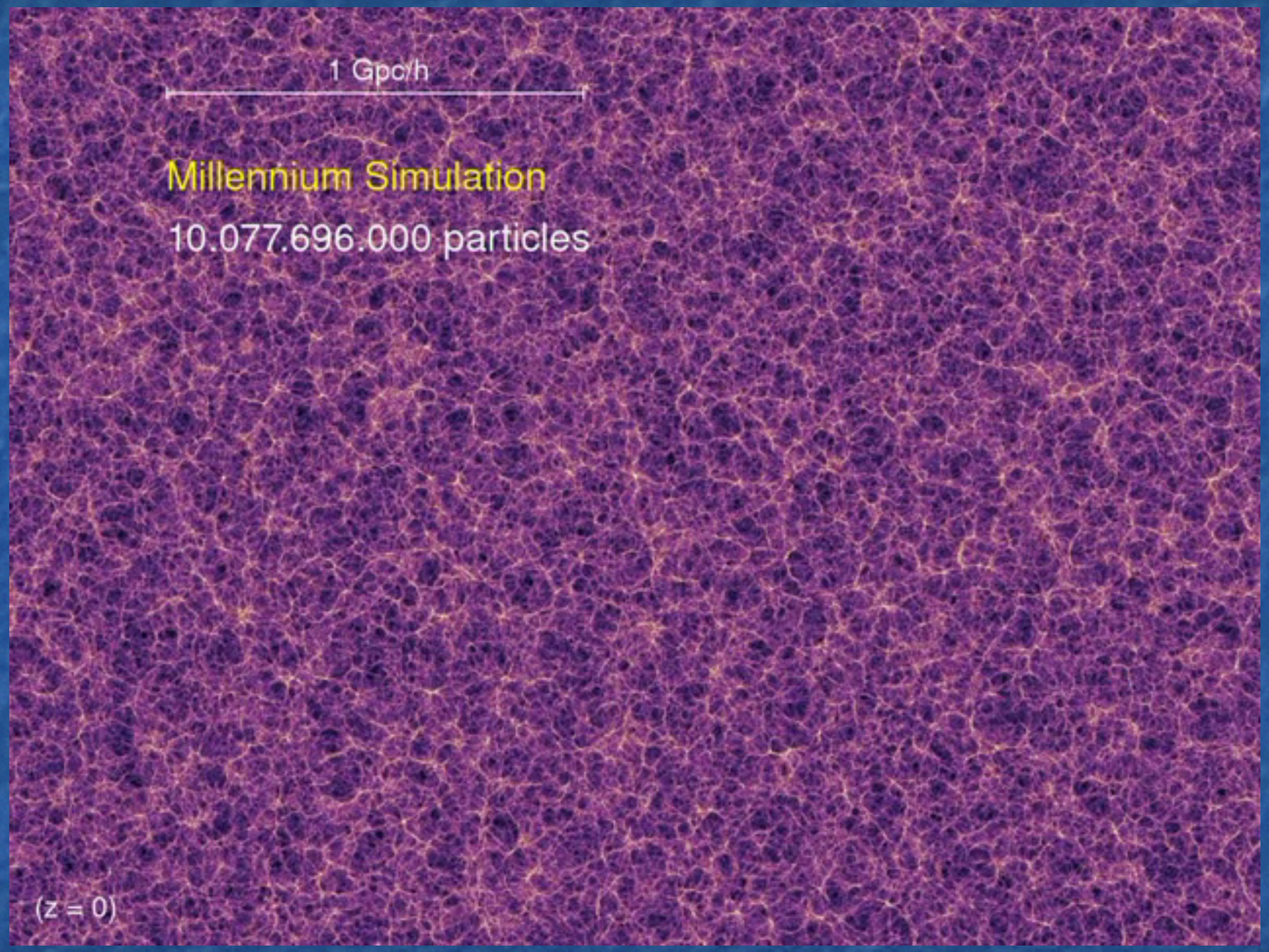
December

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15 Cambrian Explosion (burst of new life forms)	16	17 Emergence of first vertebrates	18 Early land plants	19	20 First four-limbed animals	21 Variety of insects begin to flourish
22	23	24 First dinosaurs appear	25 First mammalian ancestors appear	26	27 First known birds	28
29 Dinosaurs wiped out by asteroid or comet	30	31 10:15am Apes appear 9:24pm First human ancestors to walk upright 10:48pm Homo erectus appears 11:54pm Anatomically modern humans appear 11:59:45pm Invention of writing 11:59:50pm Pyramids built in Egypt 1 second before midnight: Voyage of Christopher Columbus				

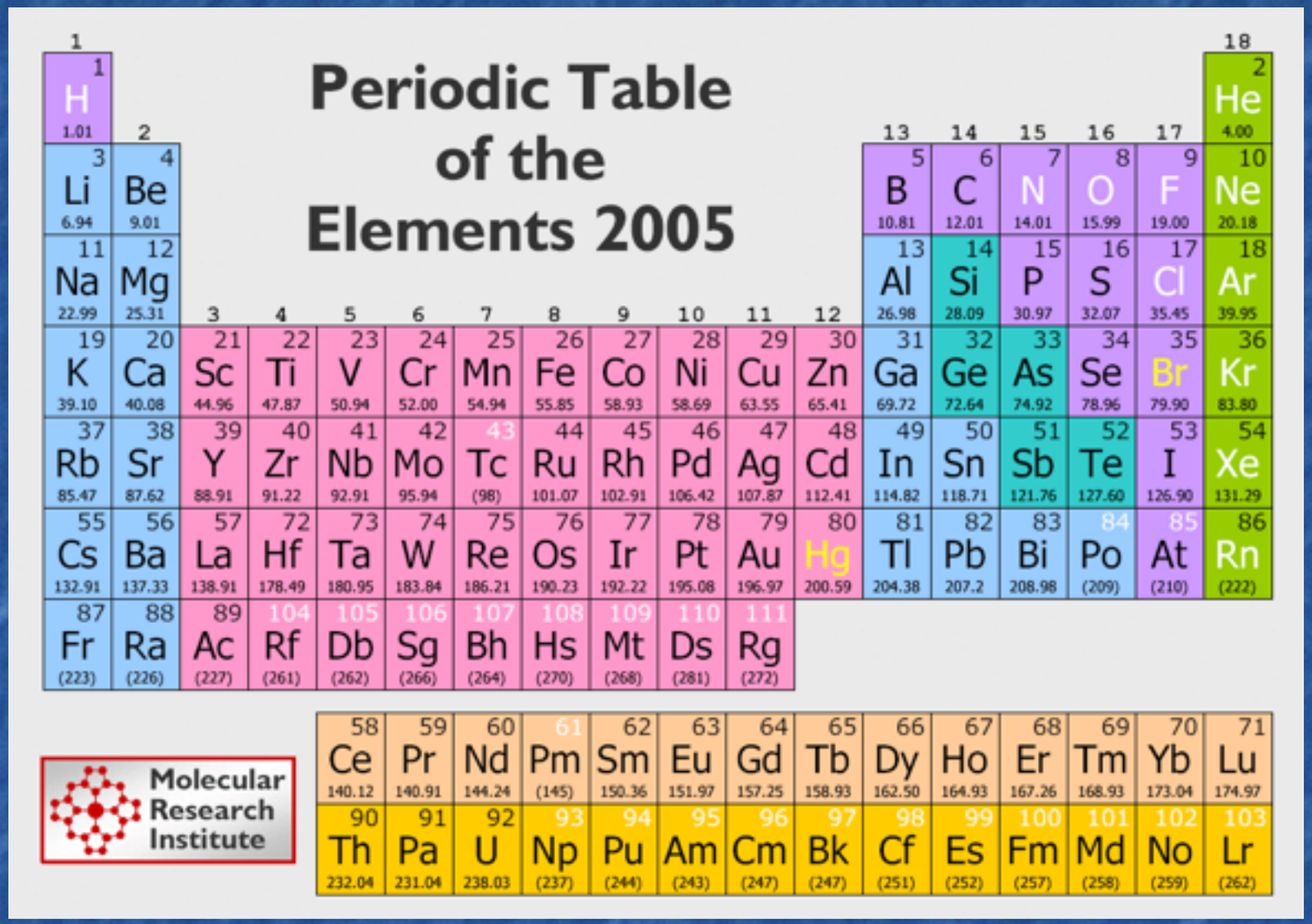
How big is the Universe?

- The age of the Universe is almost 14 billion years.
- A photon of light emitted at the Big Bang would have travelled 14 billion light years in that time.
- When we look out 14 billion light years into the Universe we see no edge or end to the distribution of galaxies.
- We therefore conclude that the Universe is larger than our current horizon and may be much larger than we can observe.
- We define the observable Universe as the sphere extending 14 billion light years from our location on Earth.


500 Mpc/h
25 Mpc/h
5 Mpc/h
Millennium Run
10.077.696.000 particles
Springel et al. (2004)
VIRGO
Max-Planck Institut für Astrophysik

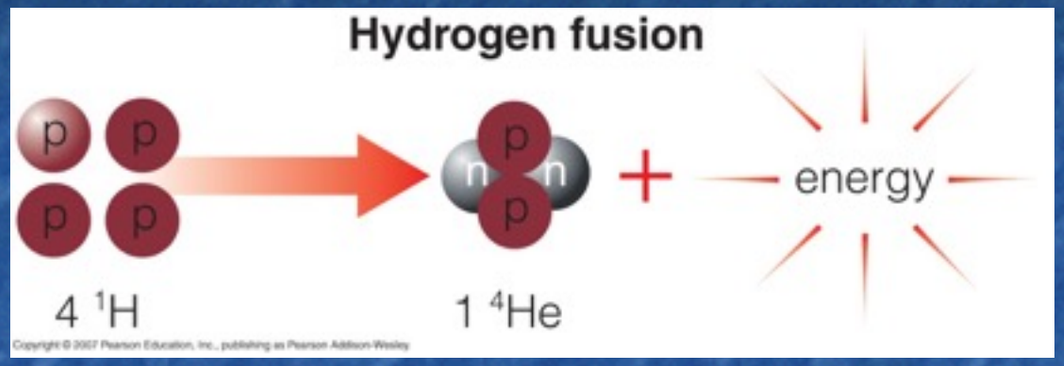

1 Gpc/h
Millennium Simulation
10.077.696.000 particles
(z = 0)

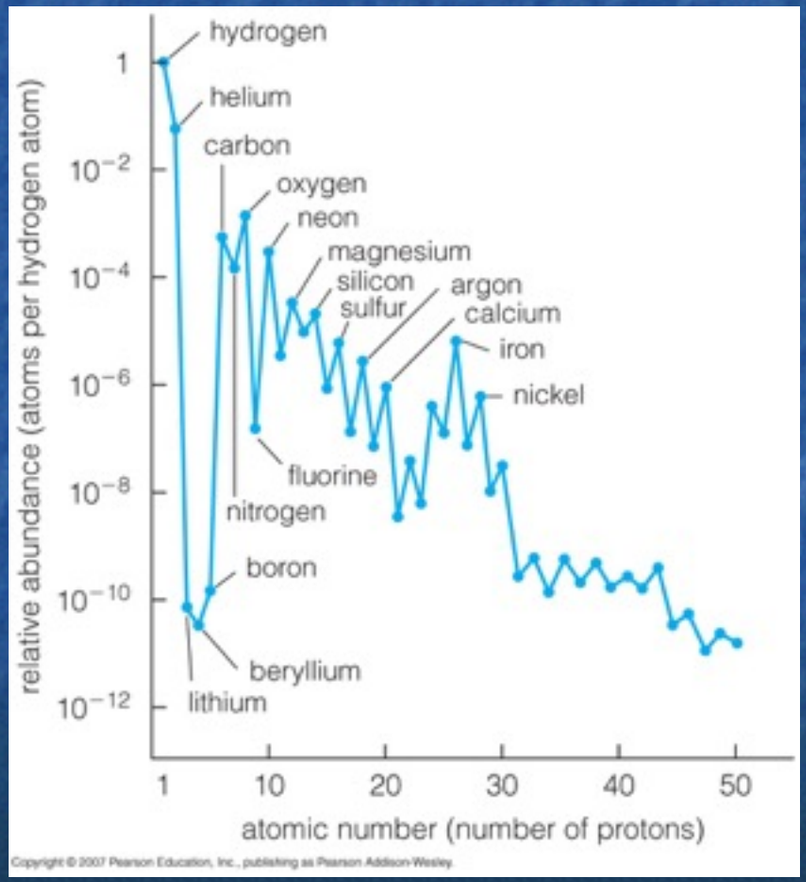
What is the Universe made of?



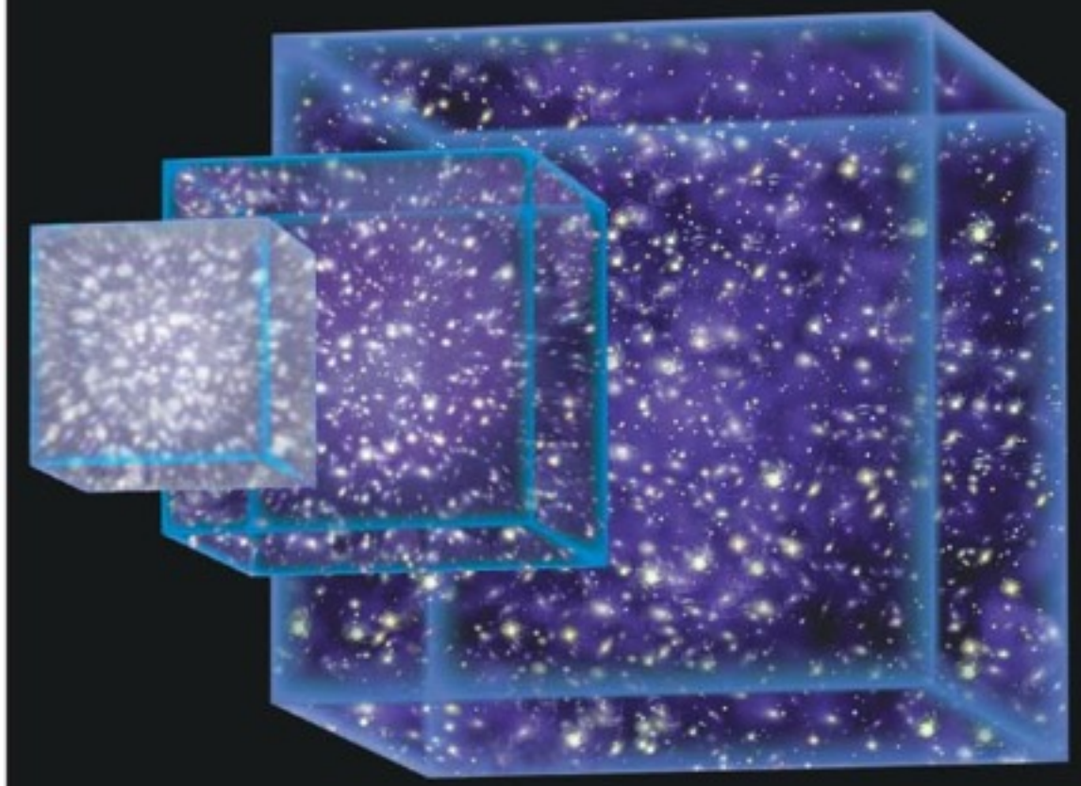
- The Periodic Table lists all the elements occurring on Earth.
- The early Universe consisted of Hydrogen, Helium (and a tiny amount of Lithium).
- How were the remaining elements created?
- In stars, via nuclear fusion occuring in their centres or created in vast nuclear explosions at the end of a stellar life - supernovae.

"We are all star stuff"





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.*

Life Cycles of Stars. *Many generations of stars have lived and died in the Milky Way.*

Stars are born in clouds of gas and dust; planets may form in surrounding disks.

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.

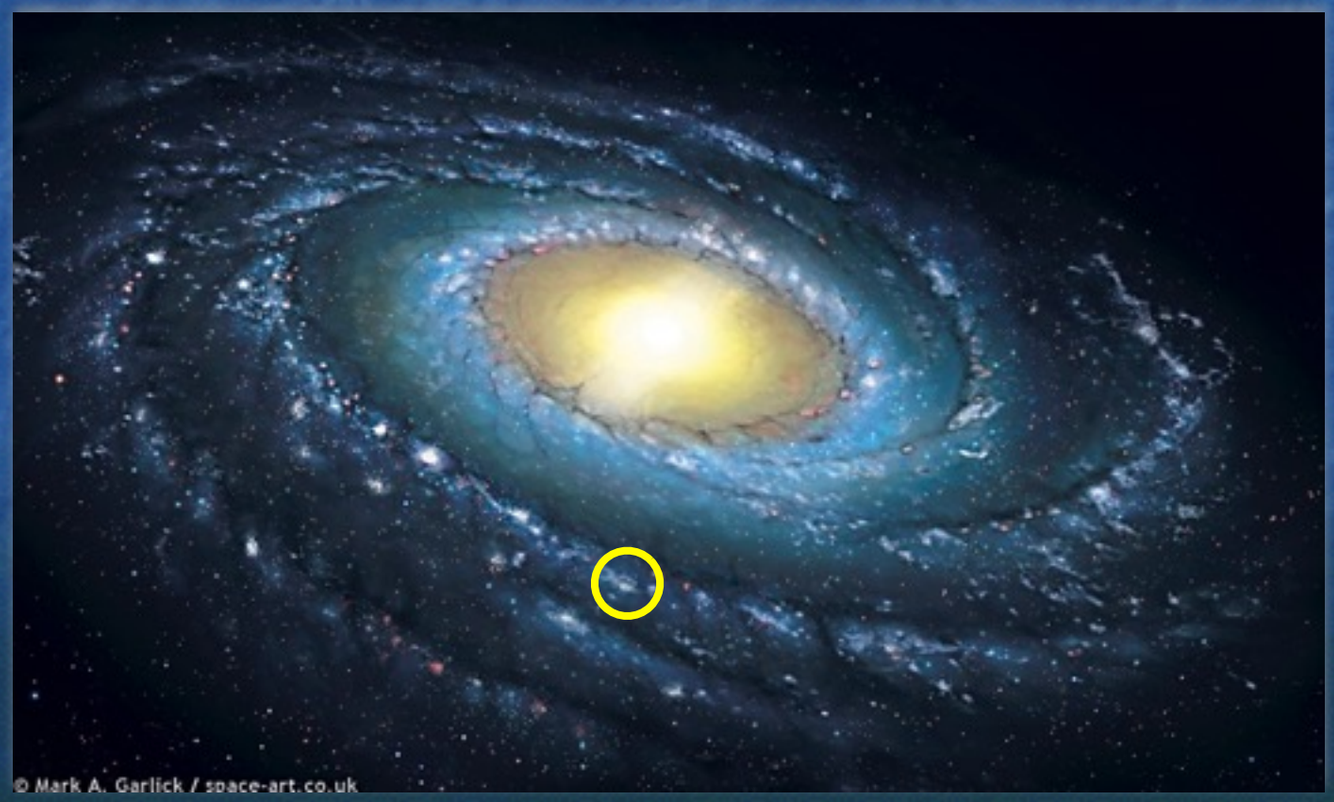
Earth and Life. *By the time our solar system was born, about 4 $\frac{1}{2}$ billion years ago, about 2% of the original hydrogen and helium had been converted into heavier elements. Thus, we are "star stuff," because we and our planet are made from elements manufactured in stars that lived and died long ago.*

The Milky Way Galaxy

www.gigagalaxyzoom.org

The Prospects of Detecting Life Elsewhere in the Milky Way

- To date, nearly all of the extra-solar planets we've been able to find lie within 3000 light years of us
  - for comparison, the centre of the Milky Way is about 25,000 light years away
- As technology improves, we will be able to probe to larger distances



Detecting Life Beyond the Milky Way

- The nearest large galaxy (Andromeda) is about 2.2 million light years away
- It is therefore much more difficult to search for direct signs of life in Andromeda or other galaxies
- Even if we could, the information we collect would be millions of years out of date!