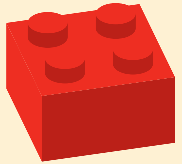
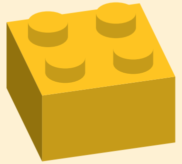
BUILD YOUR OWN UNIVERSE

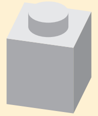
You will need:



At least 10,000,000,000,000,00
0,000,000,000,000,000,000,00
0,000,000,000,000,000,000,00
0,000,000,000,000,000,000,00
0,000 x
Down quarks



At least 10,000,000,000,000,000,
000,000,000,000,000,000,000,00
0,000,000,000,000,000,000,000,
000,000,000,000,000,000,000 x
Up quarks



At least 10,000,000,000,000,00
0,000,000,000,000,000,000,000
,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,
000 x
Electrons

For more information on our outreach activities, go to our website
www.ph.qmul.ac.uk www.sepnet.ac.uk/outreach
or email us at ph-outreach@qmul.ac.uk

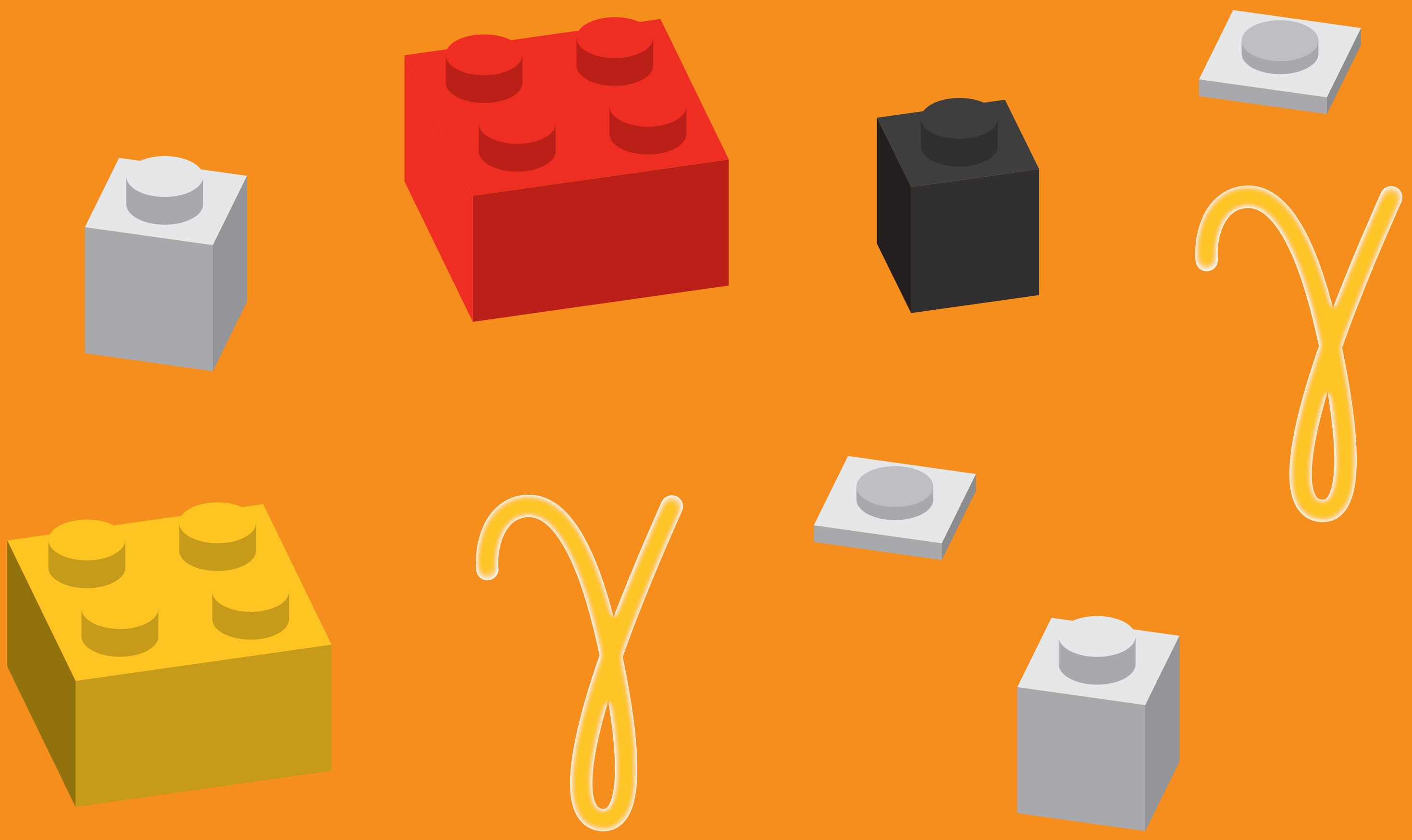
SEPnet
South East Physics Network **Outreach**

Queen Mary
University of London

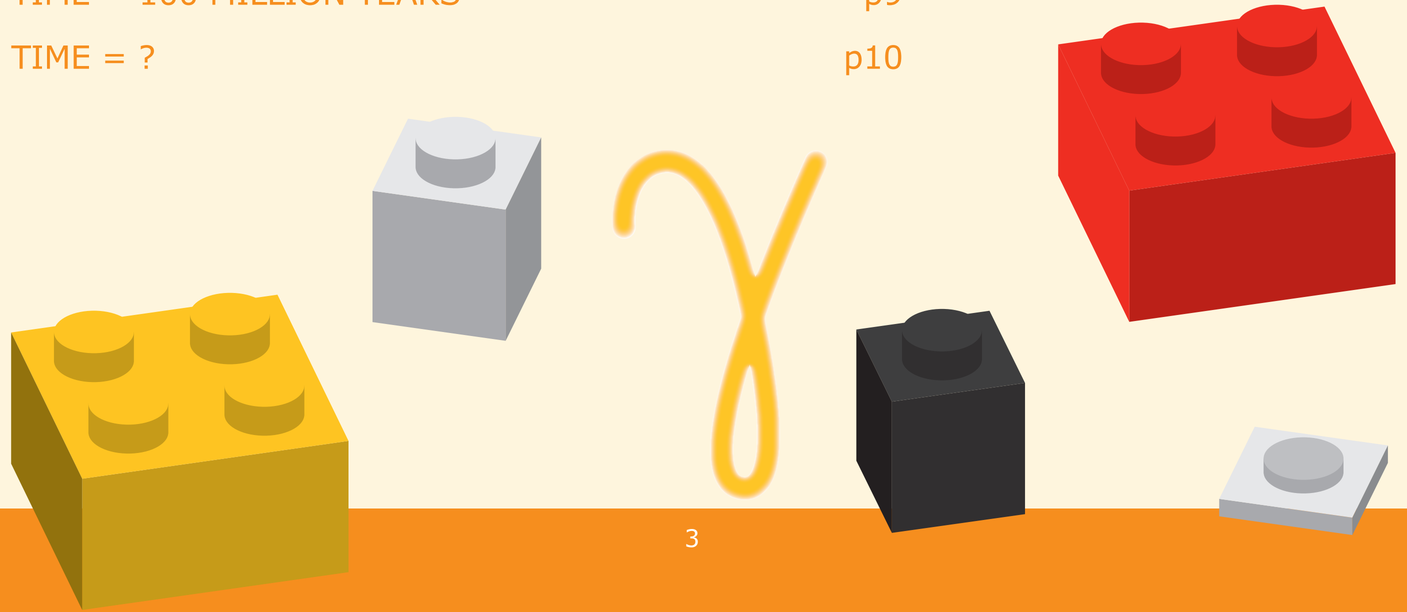
BUILD YOUR OWN UNIVERSE

SEPnet
South East Physics Network **Outreach**

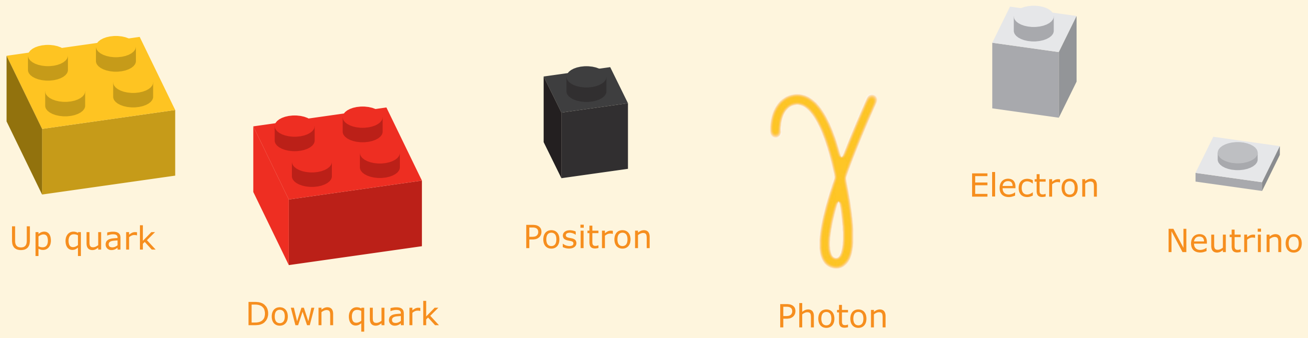
Queen Mary
University of London



BUILD YOUR OWN UNIVERSE



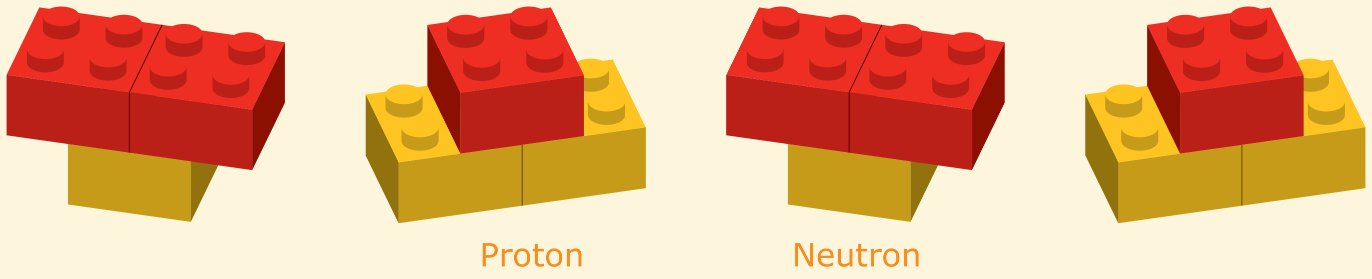
TIME = BEFORE 0.0001 SECONDS



Just after the Big Bang, the expanding Universe was a very hot, very dense jumble of different particles, smaller than atoms and molecules – much, much smaller than a grain of sand. It was so hot (more than one hundred thousand million degrees Celsius!), that these particles couldn't yet combine to form atoms. Instead, the Universe was made up of particles called 'quarks'. These intriguing particles make up everything around us, and normally stick together in groups of two or three, but at the very beginning of the Universe, they could fly about freely. There were also lots of electrons, the things which give us electricity by moving through wires, as well as their antimatter partners, positrons. Antimatter is just like matter, except that it has the opposite charge – so a positron is just as heavy as an electron, but has a charge of +1.

Photons are particles of light. This may seem strange, but if you imagine particles of light bouncing off objects into your eyes, it makes a bit more sense. Actually, light can be thought of as either a particle or a wave, depending on the situation. The last type of particle in this mix is the ghostly neutrino, a very light particle, which does not affect normal matter very much. Physicists call this jumble the particle 'soup'.

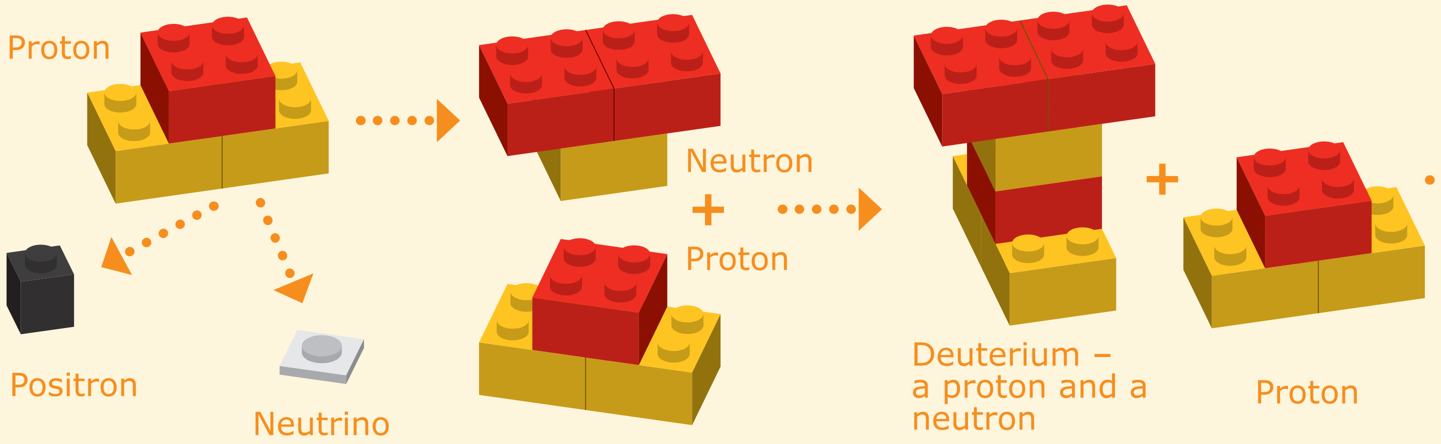
TIME = 0.0001 SECONDS - 14 SECONDS



The temperature drops down to just three thousand million degrees over these few seconds. Quarks start to stick together to form protons and neutrons, which will soon become the heart of atoms. They won't come apart again, except in very unusual situations like the Large Hadron Collider in Switzerland, where such high temperatures are recreated. However, it's still too hot for electrons to stick to the protons – every time one does, it is knocked away by an energetic particle of light.

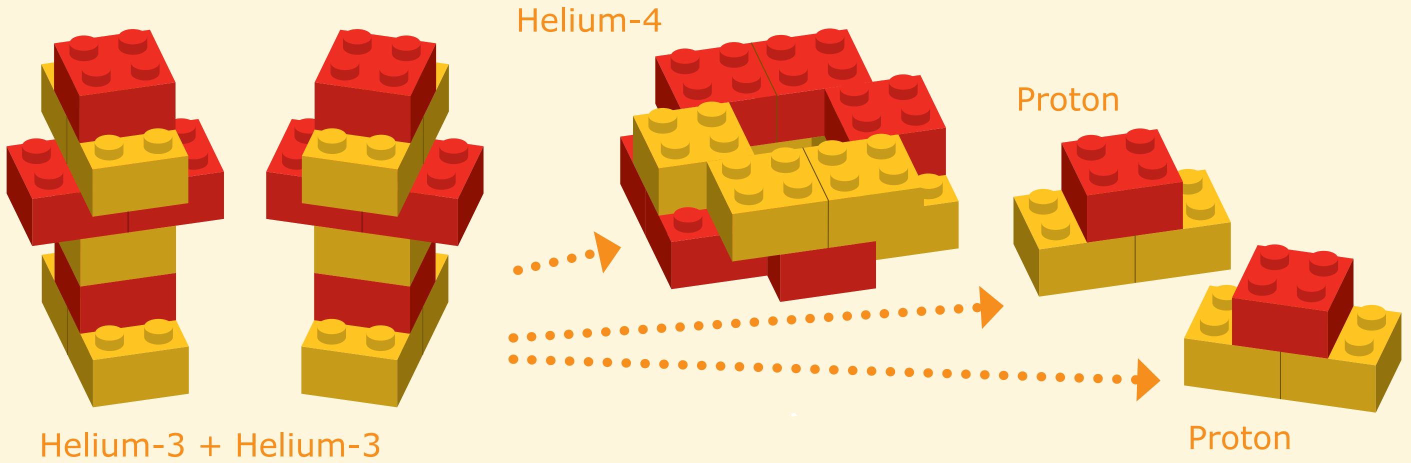
Also during this time, the positrons in the Universe are destroyed – when an antimatter particle meets its matter twin, they explode in a flash of energy (called annihilation). We don't quite understand why, but there must have been more electrons than positrons, or they would have all destroyed each other, and we wouldn't be here!

TIME= 3 MINUTES - 20 MINUTES



Now the Universe is a little cooler, protons and neutrons start to stick together, making heavier elements, like helium, and releasing energy. This process is called fusion. This process carries on until the Universe has grown so big that it is too cold for this process to continue.

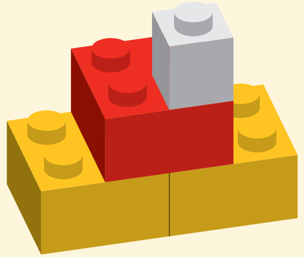
We can estimate how much of each element this process would have made, and comparing these estimates to what we see gives us evidence for the Big Bang theory.



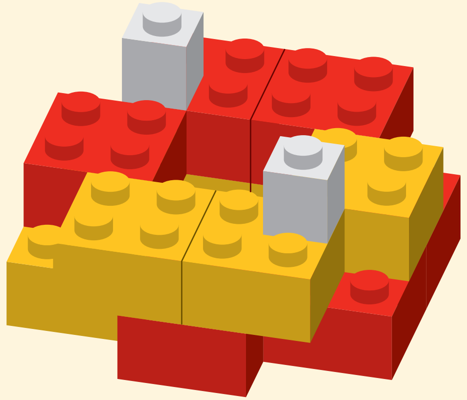
The first step that is essential for fusion is beta decay. Two hydrogen nuclei can’t stick together, because the two protons would break apart almost as soon as this nucleus was formed. What has to happen is that one proton turns into a neutron, shooting out a positron, and then this neutron can stick to another proton, which is a much more long lasting nucleus. This makes deuterium, a heavy version of hydrogen.

If we add another proton to this, we get helium-3. Finally, once we have two helium-3 nuclei, we can combine them to make helium-4, the most common type of helium. The only difference between these two nuclei is the extra neutron in helium-4.

TIME = 379,000 YEARS



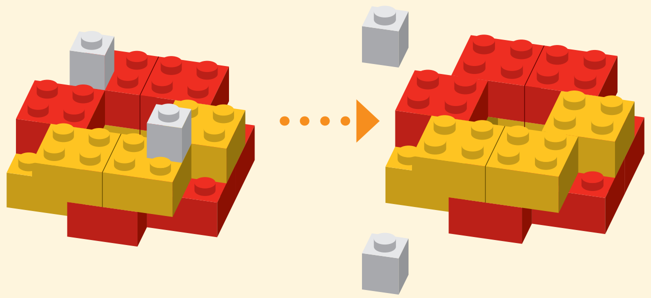
Hydrogen atom



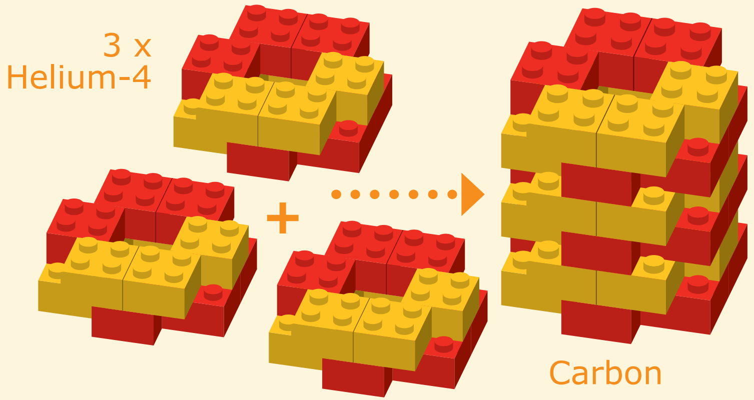
Helium atom

For the first time, temperatures are cool enough for electrons to stick to the nuclei formed in the first 20 minutes after the Big Bang. The most important thing about this is that it means that light can travel without hitting anything. If you were in the Universe before atoms formed, you wouldn't have been able to see your hand in front of your face, because light bouncing off your hand would bump into other things before it got to your eye, like on a very foggy day. When atoms form, light can travel in straight lines straight from your hand to your eye, and you would suddenly be able to see clearly. The light which escaped at this time can still be seen today, as the Cosmic Microwave Background, which provides further evidence for the Big Bang.

TIME = 100 MILLION YEARS



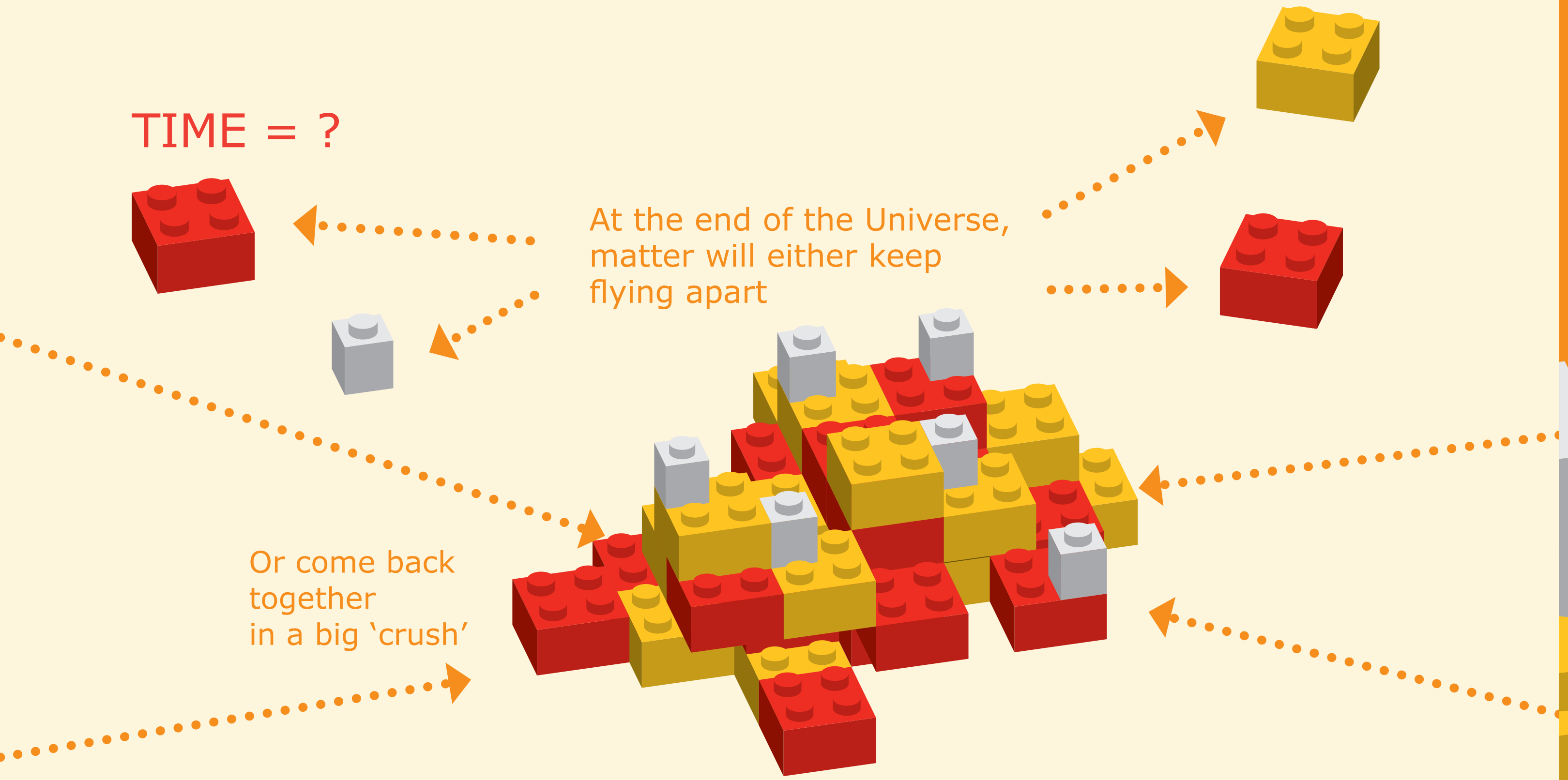
It gets hot enough
to remove electrons



And then so hot,
fusion can start

For millions of years, the Universe has been dark, with no stars shining. Slowly, clumps of matter have been growing, using gravity to attract more matter, and getting hotter and denser. After about 100 million years, these clumps are hot enough for fusion to start, like it did in the 20 minutes after the Big Bang. The big difference between fusion after the Big Bang and inside these stars is that stars get hotter rather than colder, so that even heavier elements can be formed. One of the most important of these elements is carbon, made by combining three helium nuclei. This is the basic building block for all life in Earth. It is spread throughout the Universe when the stars die, producing massive explosions, throwing the elements across space.

TIME = ?



We really don't know what will happen at the end of the Universe. It is possible that there won't be an end, and that all of the galaxies will go on flying apart (like they are now) forever, and the Universe will continue to get bigger and bigger. Another theory is that at some point, the Universe will start to get smaller, and all of the stuff in the Universe will fly back together in a big crunch. But don't worry – we don't know when it will be, but it will certainly be billions of years from now!