

# 3.1

## THRESHOLD 3— NEW CHEMICAL ELEMENTS

**0:13–0:41** After Threshold 2, the Universe had lots of stars, but most of space was still cold, dark, and mostly empty. **VERY LITTLE DIVERSITY** The Universe consisted almost entirely of two types of atomic matter, hydrogen and helium. These were both light gases and one of them was totally inert. Like a painter with just two colors, one of which won't mix, it was impossible to make anything very interesting.

**0:41–1:23** **HIGH TEMPERATURES** The Universe needed more colors, more chemical elements. And that was the work of Threshold 3. Making new elements meant fusing more protons and neutrons together. To do that, you needed very high temperatures which could only be found inside massive stars that were aging or dying.

Only they have the right Goldilocks Conditions for Threshold 3. Why? Well, large stars have so much

mass that they can create enormous pressures and temperatures. Those temperatures get cranked even higher when large stars run out of hydrogen.

When that happens, fusion stops at the center and the star collapses like a burst balloon. If the star was big enough, the collapse is huge, creating such high temperatures that helium nuclei can fuse into nuclei of carbon.

When the star has used up its helium, it collapses again and the cycle starts over. The star heats up and starts to fuse carbon to form oxygen. It collapses again, then does the same to create other elements like silicon, nitrogen, and eventually iron.

If it's a really, really big star, it will finally die in what's called a supernova. That's an explosion so hot and so energetic that for a while, it'll shine like an entire galaxy and will produce enough heat to form all the other elements of the periodic table. Then the supernova scatters these new elements into space and voila, we have a Universe with lots of different elements.

Threshold 3 was crossed for the first time when the first large star died and it's still being crossed today as billions upon billions of large stars die, scattering the raw materials needed to build wondrous new forms of complexity.

**1:23–1:59**

**FUSION OCCURS**

**1:59–2:43**

**ELEMENT FACTORIES**