The ratios of elements found in the oldest gas clouds in the universe contain one of the primary pieces of evidence for the big bang. While stars turn light elements into heavy elements (and supernovae generate even heavier elements), they aren't the sole source of atoms heavier than hydrogen. This is observed most strongly in the abundance of helium. About 25% of the mass of gas in the universe is helium, but stellar fusion in main sequence stars like the Sun hasn't had enough time since the big bang to generate this much Helium. Helium also shows a uniform distribution throughout the Milky Way and in other galaxies. By contrast, the abundance of heavier elements, which are generated in stars and supernovae, decreases with distance from the center of the Milky Way and is correlated with the number of supernovae. In other words, there is too much helium in the universe to be explained by stellar fusion — and the distribution also can't be explained with stellar nucleosynthesis. What stars and their stellar remnants can't explain, the big bang explains instead.

Russian physicist George Gamow began speculating about the consequences of the big bang model in the 1940s. He realized that the density and temperature predicted for the early phases of the big bang would provide just the right conditions to produce helium nuclei by the fusion process. The creation of deuterium and helium, along with trace amounts of lithium and beryllium, in the first 225 seconds after the big bang is called cosmic nucleosynthesis.

In the first moments of the universe, the temperature was billions of degrees. This was so hot that atoms were entirely ionized. Electrons and nuclei couldn't bind together, so the universe was a dense hot broth of radiation and particles undergoing constant collisions. The entire universe was contained in a volume about the size of the Sun! After about a minute, when the temperature had fallen to a billion degrees, nuclear reactions began to take place. Initially, neutrons and protons combined to form deuterium nuclei, symbolized as ${}_2H$ and sometimes called heavy hydrogen. Deuterium would then capture another neutron to make tritium (${}_3H$, one proton, and two neutrons) or another proton to make helium-3 (^{3}He, two protons, and one neutron). After one more stage, helium-4 nuclei (^{4}He) were created, using up almost all the available neutrons. This process was complete in less than four minutes after the big bang. In this brief period, 25 percent of the regular mass of the universe had turned into helium. During the next half-hour, tiny amounts of lithium-7 (^{7}Li) and beryllium-7 (^{7}Be) were created. After this, the reactions stopped. The universe became too cool and diffuse to synthesize heavier elements. In the simple big bang model, all heavier elements were produced much later, in the interiors of stars.

Astronomers have compared the abundances predicted by the big bang theory with observations for four light elements — helium-4, deuterium, helium-3, and lithium-7. Since some of these elements are created (and destroyed) in stars, pristine parts of the universe must be found to measure their abundance as left by the big bang. The abundances relative to hydrogen are 0.15 for helium-4, 2×10^{-5} for deuterium, 10^{-5} for helium-3, and 3×10^{-10} for lithium-7. Remarkably, all four measured abundances agree with a simple hot big bang model with only one variable: the density of ordinary matter relative to photons. Observations of the real universe match a very narrow set of theories, where there are a billion photons for every matter particle in the universe. This extraordinary success shows not only that the universe did undergo the big bang, but it shows that we can understand the details of the earliest, unobservable moments of the universe.

The most direct way to measure space curvature is to use the microwave background radiation. As a relic from the first 2% of the age of the universe, these waves have been traveling through space for billions of years. The most prominent ripples in the microwave background have an angular size of about 1º. At a time 300,000 years after the big bang, this represented the size of the first structures that were going to form in the still-hot universe. In a positively curved universe, angles subtended by distant objects are larger than they would be in flat space. You can think of this as the positive magnification of a beam of photons. In a negatively curved universe, angles subtended by distant objects are smaller than they would be in flat space. You can think of this as negative magnification. Results from the Boomerang balloon experiment in 1999, and several others that soon followed, showed that the size of the most prominent microwave fluctuations exactly matched the predictions for no curvature. These results were confirmed and refined by the WMAP and Planck space missions. No space curvature is detected at a 1% level; space seems to be flat.

Microwave background measurements indicate that space is flat. This result is surprising because astronomers have not found enough matter in the universe, light or dark, to create flat space-time. The result is renewed interest in big bang models that incorporate vacuum energy in the form of a cosmological constant. This extra repulsive force can act to smooth out space. In other words, the definition of Omega, the density parameter, should be extended to include other components of the universe that can affect space curvature. The best interpretation of all the available evidence is that $\Omega_{tot} = 1$ and space is flat. However, there is only enough normal and dark matter on any scale to add up to $\Omega_{matter} = 0.3$. The observations of Type I supernovae indicate that the other major constituent of the universe is vacuum energy, also referred to as the cosmological constant, with a value of $\Omega_{vacuum} = 0.7$. Radiation, in the form of the cosmic microwave background, is a negligible contributor. As you can see, the sum of these two components corresponds to flat space.