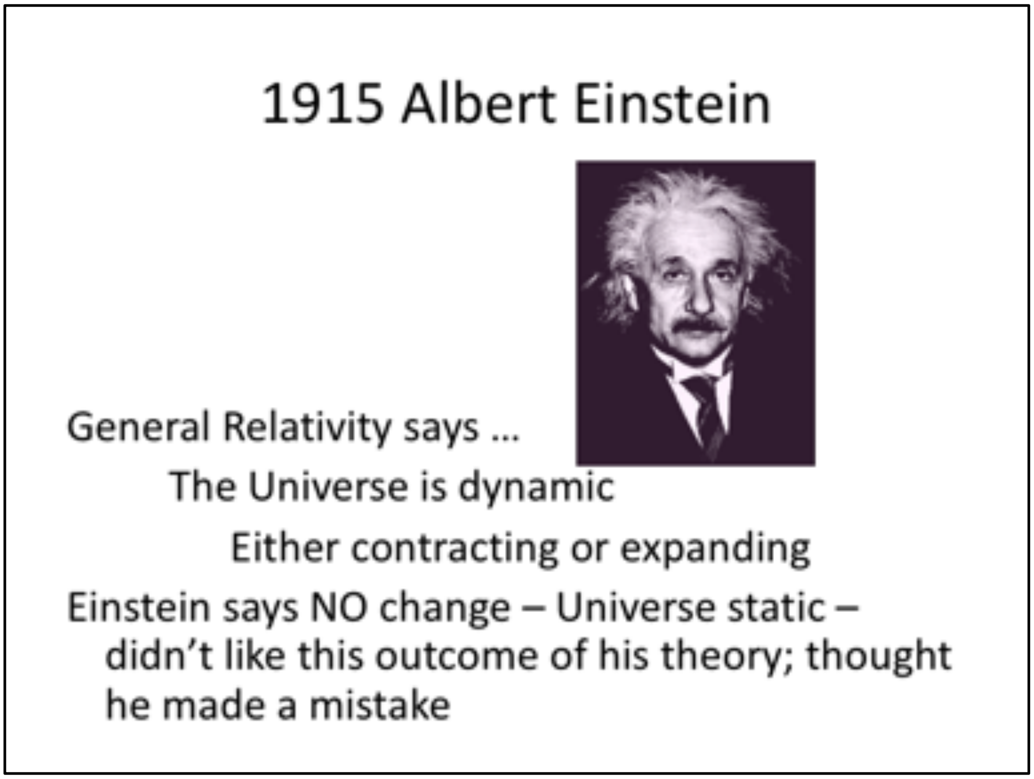
There are many galaxies



His theory of general relativity says that when you measure length, time and mass, where you are matters. Your motion and thus these measurements are relative to other things. Everything is in motion, you on the earth, the earth in the solar system, the Sun in the Milky Way. When you measure velocity (for example) it is relative to some point of reference, such as the Earth. That point of reference may itself be moving. You have to identify the point of reference, what we call "frame of reference."

In this theory, the speed of light DOES NOT CHANGE, in any frame of reference. It stays the same. The other measurements are relative, thus "relativity."

Carrying out this theory, it says the Universe is either contracting or expanding – it is not static. Einstein thought this was wrong and in 1917 stuck a constant in his equations to counteract it.

1916 Vesto Slipher

Finds spectra of “nebula” are shifted toward red.
Doesn’t know “nebula” are galaxies.

He doesn’t really know what this indicates, just that it is a characteristic of most “nebular” which are really galaxies (He doesn’t know that yet, not till 1924).

1927 Georges Lamaitre

Writes article in obscure journal connecting Einstein's equations and Slipher's red shifts

The Universe is expanding

No One Pays Attention

At this time, Einstein, while not taking exception to the mathematics of Lemaître's theory, refused to accept the idea of an expanding universe; Lemaître recalled him commenting "Vos calculs sont corrects, mais votre physique est abominable"[4] ("Your math is correct, but your physics is abominable.")

In 1930, Eddington published in the Monthly Notices of the Royal Astronomical Society a long commentary on Lemaître's 1927 article, in which he described the latter as a "brilliant solution" to the outstanding problems of cosmology.[5] The original paper was published in an abbreviated English translation in 1931, along with a sequel by Lemaître responding to Eddington's comments.[6] Lemaître was then invited to London in order to take part in a meeting of the British Association on the relation between the physical Universe and spirituality. There he proposed that the Universe expanded from an initial point, which he called the "Primeval Atom" and developed in a report published in Nature.[7] Lemaître himself also described his theory as "the Cosmic Egg exploding at the moment of the creation"; it became better known as the "Big Bang theory," a term coined by Fred Hoyle.

1928 Edwin Hubble

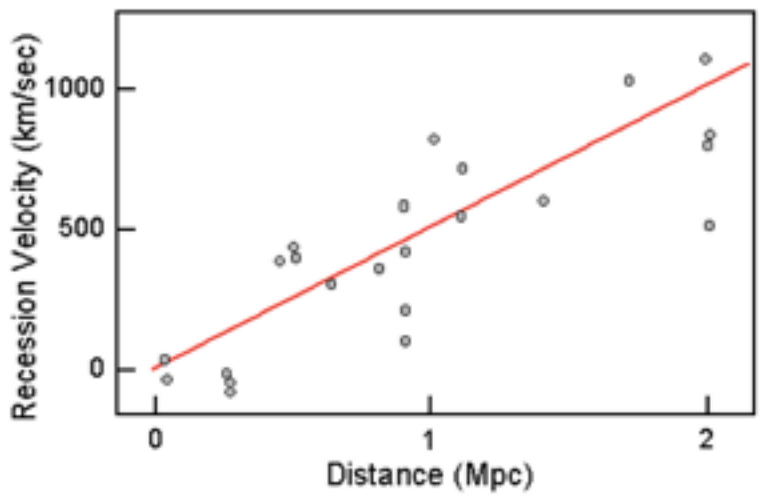
Finds distance to 25 galaxies
& analyzes the distance
and red shift of each galaxy

Galaxies are moving away
from us & each other

Universe IS expanding

Hubble still looking at galaxies; He finds relationship – most galaxies moving away from us and further ones moving faster

Hubble's Data (1929)



Vho Left Ozarks Mountains to Study

* * * * * * * * * * * * * * *

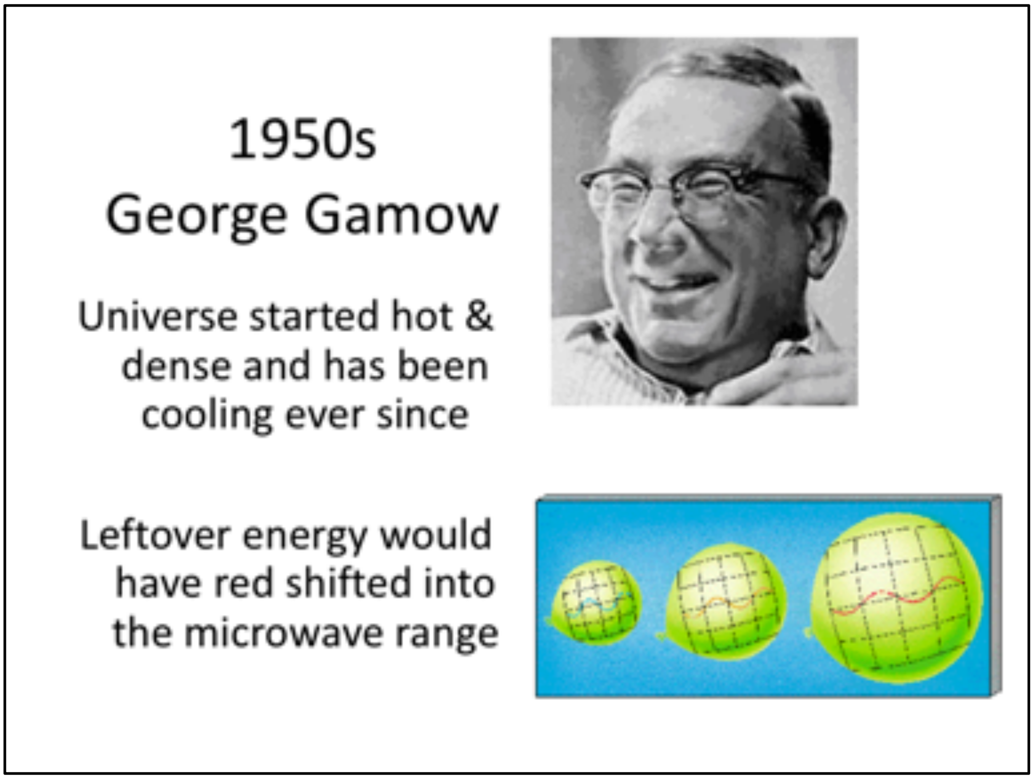
auses Einstein to Change His Mind

. CLAUSEN
Staff Writer
Feb. 3.—Two

thing of the past, and that he is working on a new theory.
Around his boyhood home, in

ster, to become an astronomer. At the University of Chicago, he proved a leader among youths, winning his

Einstein gives in – goes out to California in 1931 to look through the telescope at Mt Wilson in southern California and talk with Hubble.



The influential Alpher-Bethe-Gamow paper outlined how the present levels of hydrogen and helium in the universe (which are now thought to make up over 99% of all matter) could be largely explained by reactions that occurred during the "Big Bang". This lent theoretical support to the Big Bang theory, although it did not explain the presence of elements heavier than helium (this was later explained by Fred Hoyle).In the paper, no estimate of the strength of the present day residual cosmic microwave background radiation (CMB) was made. But shortly thereafter, Alpher and Robert Herman predicted that the afterglow of the big bang would have cooled down after billions of years, filling the universe with a radiation 5 degrees above absolute zero.

Robert Dicke & David Wilkinson & Peter Roll

"Well, boys. We've been scooped!"

Dicke, Peebles recreate Gamow's work. Then Dicke assigns Wilkinson and Roll to figure out how to look for the cmb, so they start planning to build a telescope to search for it. But before they could find it …

Dicke, Peebles, Wilkinson and Roll have a lunchtime meeting to discuss the design of an apparatus to detect the cmp. Dicke gets a phone call from astronomer Arno Penzias. Penizas had seen a paper and called to ask about it. Dicke, Wilkinson and Roll drive over to Bell labs (30 miles) to see the telescope and results. It fit their prediction, radiation at 3K. Both groups publish companion papers confirming the cmb.

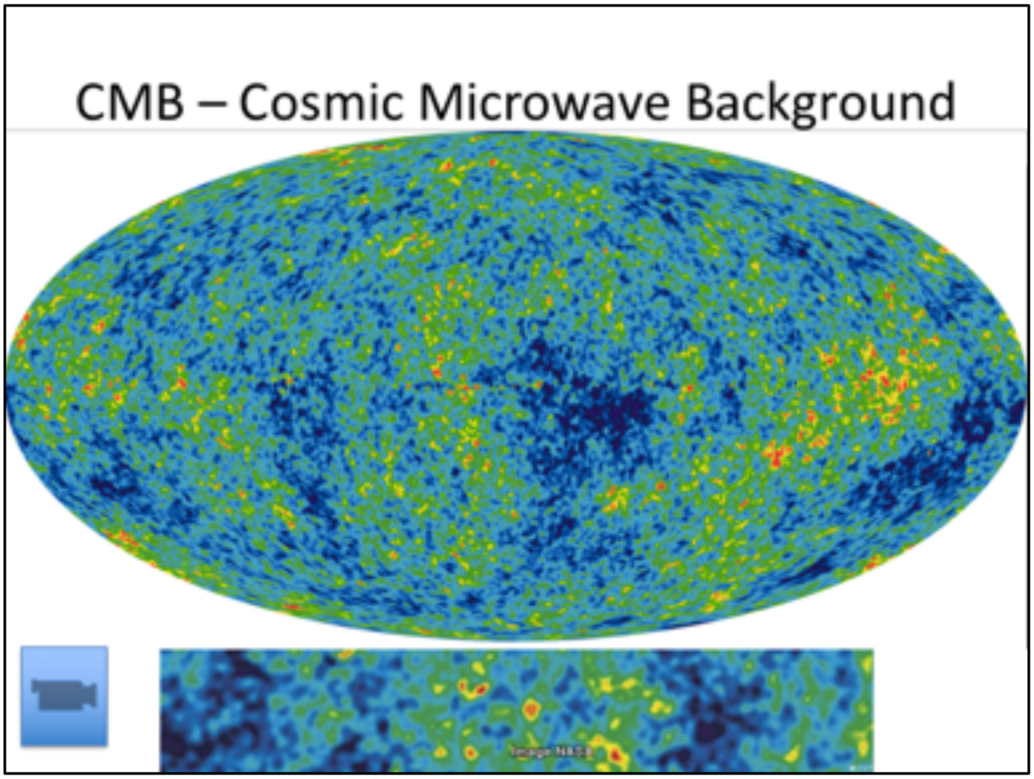
1964 Robert Wilson & Arno Penzias

They find persistent microwave hiss coming from all directions

Cosmic Background Radiation

Got Nobel prize for this discovery but they were not the ones who came up with the idea. They just happened to find it, beating out the 2 that actually went looking for it.

Twoemployees of Bell Labs had had their eye on an antenna. Arno Penzias (b. 1933), a German-born radio astronomer, joined Bell Labs in 1958. He had done his PhD on using masers (microwave amplification by stimulated emission of radiation) to amplify and measure radio signals from the spaces between galaxies. He knew the Holmdel antenna would also make a great radio telescope and was dying to use it to continue his observations, but he pursued other research while the antenna was booked for commercial use. Another radio astronomer came to Bell Labs in 1962 with the same idea. Robert Wilson (b. 1936) had also used masers to amplify weak signals in mapping radio signals from the Milky Way. The launch of Telstar in 1962 gave both researchers what they wanted: the Holmdel antenna was freed up for pure research.
When they began to use it as a telescope they found there was a background "noise" (like static in a radio). This annoyance was a uniform signal in the microwave range, seeming to come from all directions. Everyone assumed it came from the telescope itself, which was not unusual. It hadn't interfered with the Echo system but Penzias and Wilson had to get rid of it to make the observations they planned. They checked everything to rule out the source of the excess radiation. They pointed the antenna right at New York City -- it wasn't urban interference. It wasn't radiation from our galaxy or extraterrestrial radio sources. It wasn't even the pigeons living in the big, horn-shaped antenna. Penzias and Wilson kicked them out and swept out all their droppings. The source remained the same through four seasons, so it couldn't have come from the solar system or even from a 1962 above-ground nuclear test, because in a year that fallout would have shown a decrease. They had to conclude it was not the machine and it was not random noise causing the radiation.
Penzias and Wilson began looking for theoretical explanations. Around the same time, Robert Dicke (1916Ð1997) at nearby Princeton University had been pursuing theories about the big bang. He had elaborated on existing theory to suggest that if there had been a big bang, the residue of the explosion should by now take the form of a low-level background radiation throughout the universe. Dicke was looking for evidence of this theory when Penzias and Wilson got in touch with his lab. He shared his theoretical work with them, even as he resignedly said to his fellow-researchers, "We've been scooped."



CMB is all over the sky, any direction you look in.

Oval is usually how it is represented.

Video - https://www.youtube.com/watch?v=1kqWWLpyMpY

BB not about origin of universe

"That the universe is expanding and cooling is the essence of the big bang theory. You will notice I have said nothing about an 'explosion' - the big bang theory describes how our universe is evolving, not how it began."

P. J. E. Peebles, Cosmologist
Scientific American Jan 2001

The BBT is not about the origin of the universe. Rather, its primary focus is the development of the universe over time. BBT does not imply that the universe was ever point-like. The origin of the universe was not an explosion of matter into already existing space.

Another cosmologist, the German Rudolf Kippenhahn, wrote the following in his book "Kosmologie fuer die Westentasche" ("cosmology for the pocket"): "There is also the widespread mistaken belief that, according to Hubble's law, the Big Bang began at one certain point in space. For example: At one point, an explosion happened, and from that an explosion cloud travelled into empty space, like an explosion on earth, and the matter in it thins out into greater areas of space more and more. No, Hubble's law only says that matter was more dense everywhere at an earlier time, and that it thins out over time because *everything flows away from each other." In a footnote, he added: "In popular science presentations, often early phases of the universe are mentioned as 'at the time when the universe was as big as an apple' or 'as a pea'. What is meant there is in general the epoch in which not the whole, but only the part of the universe which is observable today had these sizes." (pp. 46, 47; FAQ author's translation, all emphasizes in original)*

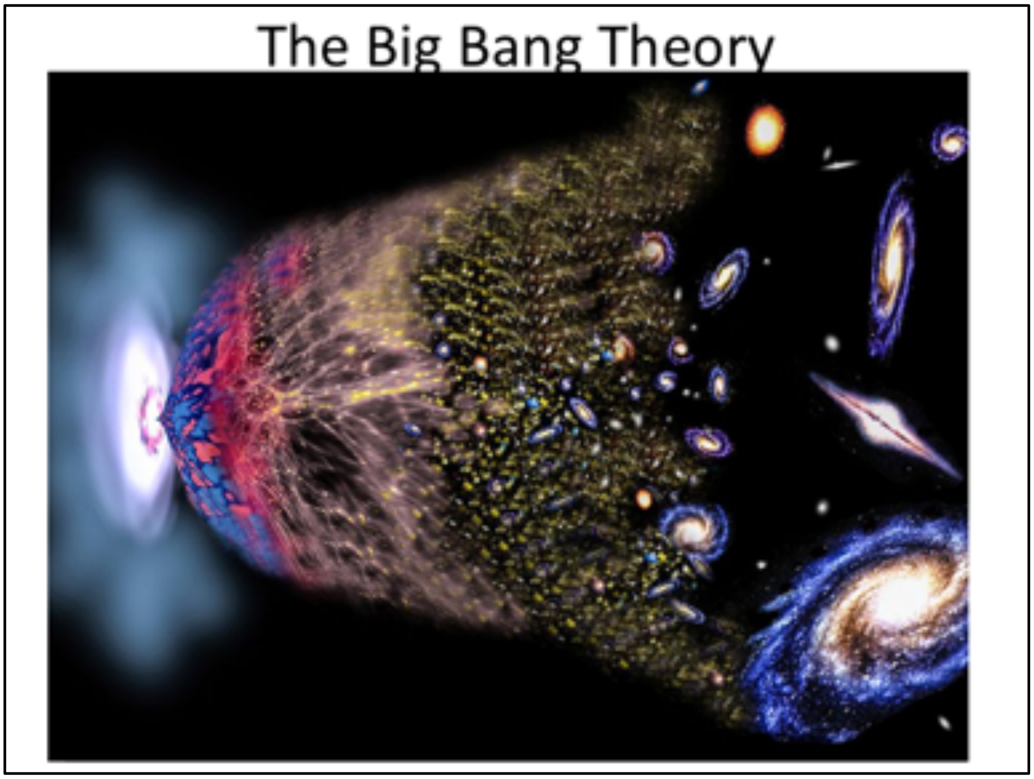
Nothing ABOUT the BANG, HOW it banged or Why it banged.

Fred Hoyle

Coined the term Big Bang, dismissing it

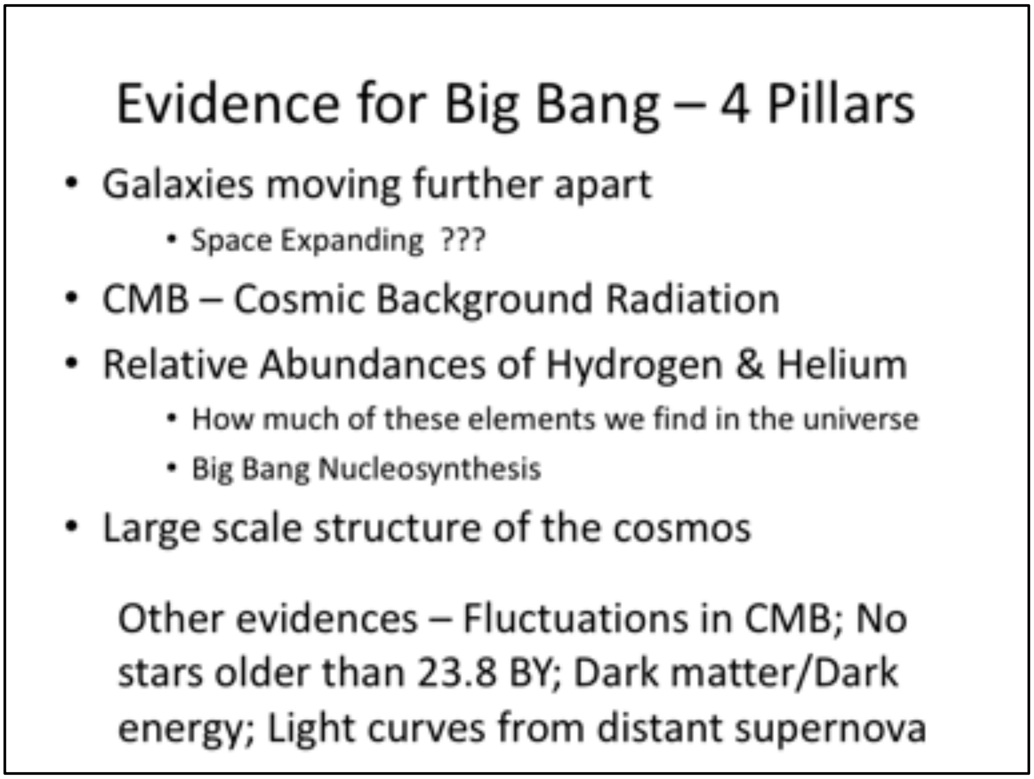
In the 1950s he gave radio talks about astronomy in England. He didn't think the Big Bang was correct. He dismissively called this idea of a primordial atom, a point that encompassed all matter, a "Big Bang" and the name stuck. He never accepted the theory until his death in 2001.

He did figure out the way elements are formed in stars – nuclear fusion



Representations of the Big Bang. The Universe evolved over time, starting out hot and dense, then cooling enough for elements to form (H and He) and progressing to nebula, stars, galaxies and cluster of galaxies.

No picture is perfect – no explosion at start, but expansion of space and time.



4 pillars of the Big Bang

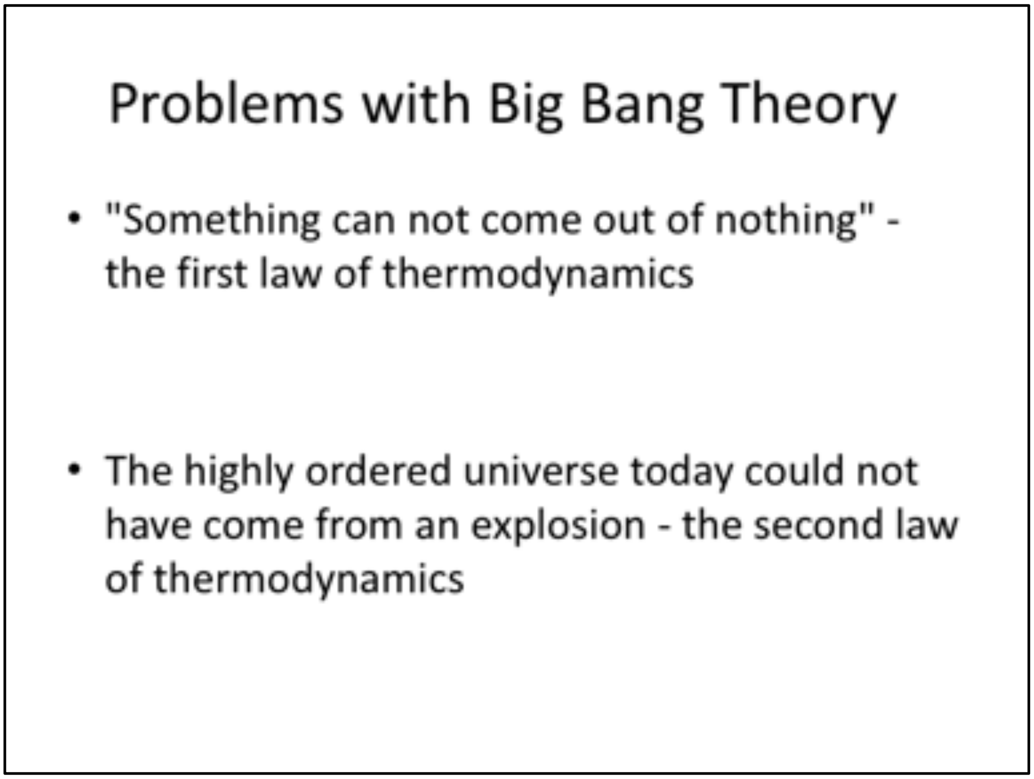
1. Galaxies moving further apart – go backwards if these galaxies are far, far away, and moving quickly away from us, this suggests that the entire Universe must have been located in a single point billions of years ago.
AND expanding space

2. CMB – light that is moving away, getting redder, past red into microwave
Theories predicted that after a Big Bang, there would have been a tremendous release of radiation. And now, billions of years later, this radiation would be moving so fast away from us that the wavelength of this radiation would have been shifted from visible light to the microwave background radiation we see today.

3. Nucleosynthesis - In the earliest moments after the Big Bang, there was nothing more than hydrogen compressed into a tiny volume, with crazy high heat and pressure. The entire Universe was acting like the core of a star, fusing hydrogen into helium and other elements.

This is known as Big Bang Nucleosynthesis. As astronomers look out into the Universe and measure the ratios of hydrogen, helium and other trace elements, they exactly match what you would expect to find if the entire Universe was once a really big star.

4. Structure of the cosmos - The final line of evidence is the formation of galaxies and the large scale structure of the cosmos. About 10,000 years after the Big Bang, the Universe cooled to the point that the gravitational attraction of matter was the dominant form of energy density in the Universe. This mass was able to collect together into the first stars, galaxies and eventually the large scale structures we see across the Universe today.



Two of the most often reasons brought up.

1. The simple statement "something can not come out of nothing" is, in itself, not very convincing. From quantum field theory, we know that something *does indeed come from nothing: to wit, "vacuum fluctuations". In the simplest case, an electron, a positron and a photon can appear effectively out of nowhere, exist for a brief time and then annihilate, leaving no net creation of mass or energy.*

There are several valid counterarguments against this: first, as already pointed out, the BBT is not about the origin of the universe, but rather its development with time. Hence, any statement that the appearance of the universe "out of nothing" is impossible has nothing to do with what the BBT actually addresses. Likewise, while the laws of thermodynamics apply to the universe today, it is not clear that they necessarily apply to the origin of the universe; we simply do not know. Finally, it is not clear that one can sensibly talk about time "before the Big Bang". "Time" is an integral part of our universe (hence the GR term "spacetime") - so it is not clear how exactly one would characterize the energy before and after the Big Bang in a precise enough way to conclude it was not conserved.

2. The standard misconception of the Big Bang is that of an explosion of matter into already existing space. This is not the case. Rather, BBT holds that spacetime itself expanded. Obviously, any statements accompanied by the claim that the Big Bang exploded to create order need to be taken with a grain of salt. Further, our everyday conceptions of "order" and "disorder" do not really apply to the physical quantity called "entropy". Indeed, as shown by Kolb & Turner, the entropy of the early universe was extremely low. This makes sense if one remembers that, in the very early stages of the universe, the distribution of matter and energy was very, very ordered, as demonstrated by the uniformity of the CMBR. As such, one could characterize the entire distribution of matter and energy in the universe with a single number (the temperature) to a very good approximation. Compare that to the universe we see now, filled with complicated, disorderly distributions of galaxies, stars and gas. The amount of entropy in these objects is enormous (recall our earlier discussion about the lack of coherent orbits for stars in elliptical galaxies and galaxies in galaxy clusters). Hence, the idea that the entropy of the universe has somehow decreased in violation of the second law of thermodynamics is largely nonsensical.

Entropy = a thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work, often interpreted as the degree of disorder or randomness in the system.