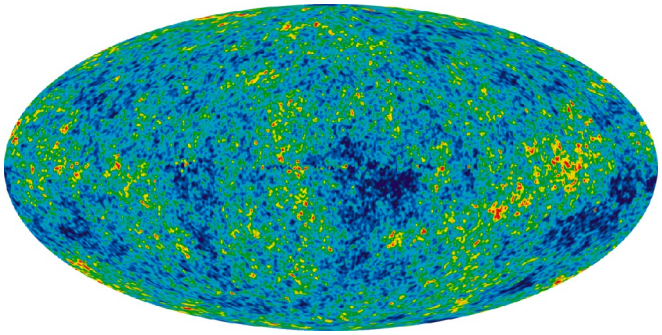
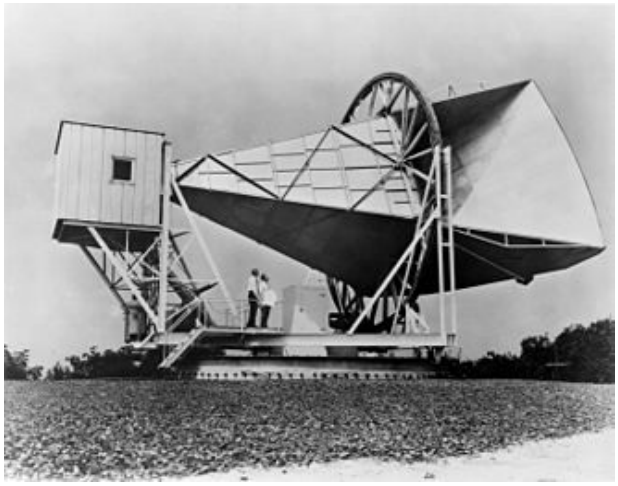
WHAT CAME BEFORE THE BIG BANG



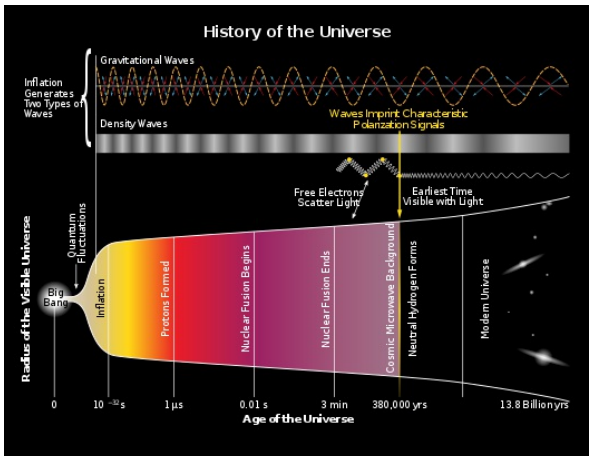
In the 13th century, **Siger of Brabant** authored the thesis The Eternity of the World, which argued that there was no first man, and no first specimen of any particular: the universe is thus without any beginning or end, and therefore eternal. Siger's views were condemned by the Pope in 1277.
As astronomical observations improved and Edwin Hubble in the 1920s confirmed changes (expansion) in the universe the subject became popular again and people started to theorize about its history.
Hermann Bondi, Thomas Gold, and **Fred Hoyle** in 1948 proposed a Steady State Model which asserts that although the universe is expanding, it nevertheless does not change its appearance over time: The universe has no beginning and no end. This requires that matter be continually created in order to keep the universe's density from decreasing.
The theory lost favor when in the mid 1960 the Microwave Background was accidently discovered by Penzias and Wilson, which seemed to point at an earlier, massive upheaval in the universe. The expression “Big Bang” was actually created by Fred Hoyle as a joke on the early theories of an explosive beginning of the Universe.



The Holmdel Horn Antenna on which Penzias and Wilson discovered the cosmic microwave background. The antenna was constructed in 1959 to support Project Echo—the National Aeronautics and Space Administration's passive communications satellites, which used large earth orbiting aluminized plastic balloons as reflectors to bounce radio signals from one point on the Earth to another.

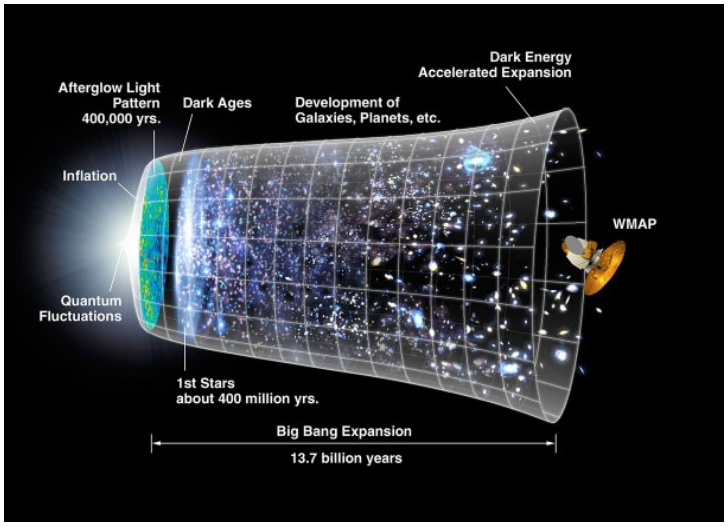
As the theory of creation evolved, it is only natural to ask what happened then before the Big Bang. For years, cosmologists answered that it was unknown, unknowable, or that there was nothing before the Big Bang, not even time. As you extrapolate our expanding universe backwards, you eventually reach a point of infinite density where the known laws of physics break down. The Big Bang theory doesn't rule out the possibility that there was some pre-existing universe from which ours sprang, but if such a thing existed, it was beyond the reach of science. But then something changed. Now, serious cosmological theories posit that the Big Bang happened within a pre-existing space, universe or network of our universe. Of course, nothing could have happened in our observable universe before it existed, but scientists today are able to conceive of events 'before' the Big Bang by widening their perspective. And for some, the push to uncover our deepest cosmic origins is tied up with another grand quest — to understand the nature of time, and why it keeps propelling us so relentlessly into the future.

So what *did* come before? There are almost as many theories as there are theorists, but they fall into a few broad categories. Some postulate a sea of rapidly expanding space that gives rise to new universes like bubbles in a pot of boiling water. Others favour a bland expanse of empty space that occasionally gives birth to baby universes full of energy and matter. In one scenario, the Big Bang was more of a Big Bounce, the comeback of a contracting older universe. And although these cosmic visions might sound more psychedelic than scientific, the faint imprints of what came before might not be as unobservable as we once thought.



Redefining the Big Bang

What we do know from observation is that on large scales, the galaxies sprinkled through the visible universe are drifting away from one another. Somehow the universe is expanding, and if you extrapolate back in time, it looks like everything was once a dense, trillion-degree soup of disembodied particles. That's the part of the Big Bang theory that remains well-established. When it was first devised, the theory made several sharp predictions, among them that the universe would contain a specific ratio of hydrogen, helium and lithium, and that radiation from the Big Bang would be detectable today in the form of a pervasive *cosmic microwave background.* Both of those were spectacularly confirmed.



A short Inflation followed by a gradual accelerating Expansion

But by the 1970s, problems appeared that made it clear the theory had to be modified. For one thing, the Big Bang failed to explain the relative homogeneity of the universe. On very large scales, galaxies are distributed through the sky the same way in all directions, as if they'd been stirred through the heavens. **But under the original Big Bang theory, it's physically impossible for them to have mixed together within the finite age of the universe. There hasn't been enough time.**

In 1981, **Alan Guth** hit on an adjustment to the Big Bang that appeared to take care of the problem — a quick burst of extremely fast expansion that would precede the normal, more leisurely expansion of the universe. Guth dubbed his idea inflation, but it seems to defy the law of conservation of energy — Guth himself famously quipped that it's the ultimate free lunch — but it's all perfectly compatible with the rules laid out in Einstein's general relativity. Energy can be positive or negative. The gravitational energy that fills space is considered negative, while the repulsive force driving inflation is considered positive. So you can start out with zero energy and get a whole lot of both positive and negative energy, and because these two add up to zero, the conservation law isn't violated.

At first, there was general agreement that the Big Bang happened first, and then a tiny fraction of a second later, inflation began. Another fraction of a second later inflation ended, starting the hot, dense phase of the universe that expanded into our universe of space, stars, and upwards of 2 trillion galaxies. But now many cosmologists refer to inflation as something that happened *before* the Big Bang. It created the Big Bang wrote MIT physicist **Max Tegmark** in his 2014 book, Our *Mathematical Universe: My Quest* for the *Ultimate* Nature *of Reality.*

At issue is what we mean by 'Big Bang'. There is some disagreement over what, exactly, the term refers to these days, says **Matthew Johnson** (York University and the Perimeter Institute for Theoretical Physics, Canada). Many agree with Tegmark that 'Big Bang' should refer only to the hot, dense state of matter that expanded and cooled into our observable universe, and not to any notion of an absolute beginning. This terminology can help separate the part of cosmology that's backed with strong evidence — the hot Big Bang and what came afterwards — from the more speculative notion of inflation. And inflation wasn't much of a bang. Tegmark describes it as a cold little swoosh.

But how did inflation begin? Cosmologist **Andrei Linde** (Stanford University), one of the first people to recognise the possibility of a multiverse, has proposed that inflation happens naturally in a wide range of situations — it's a If cosmologists can determine whether in this instant space was contracting or expanding, the result will point to vastly different pictures of a much larger, or even infinite, pre-existing physical reality. **Thus, although these cosmological theories might seem fanciful and far removed from observations, many scientists are not content to let them stay that way. As long as people keep thinking of tests that might work, these scenarios remain tethered to the great expansion of scientific knowledge.**

AK, with ‘Sky and Telescope’ and Wikipedia Notes