Confirmation of Gravitational Waves

A hundred years ago, Albert Einstein…predicted the waves' existence, inspiring decades of speculation and fruitless searching. Twenty-two years ago, construction began on an enormous detector, the Laser Interferometer Gravitational-Wave Observatory (LIGO). Then, on September 14, 2015, at just before eleven in the morning, Central European Time, the waves reached Earth.

Subgroups within the LIGO Scientific Collaboration set about validating every aspect of the detection. They reviewed how the instruments had been calibrated, took their software code apart line by line, and compiled a list of possible environmental disturbances, from oscillations in the ionosphere to earthquakes in the Pacific Rim. ("There was a very large lightning strike in Africa at about the same time," Stan Whitcomb, LIGO's chief scientist, told me. "But our magnetometers showed that it didn't create enough of a disturbance to cause this event.") Eventually, they confirmed that the detection met the statistical threshold of five sigma, the gold standard for declaring a discovery in physics. This meant that there was a probability of only one in 3.5 million that the signal was spotted by chance.

http://www.newyorker.com/tech/elements/gravitational-waves-exist-heres-how-scientists-finally-found-them

(LIGO is part of a larger effort to explore one of the more elusive implications of Einstein's general theory of relativity. The theory, put simply, states that space and time curve in the presence of mass, and that this curvature produces the effect known as gravity. When two black holes orbit each other, they stretch and squeeze space-time like children running in circles on a trampoline, creating vibrations that travel to the very edge; these vibrations are gravitational waves. They pass through us all the time, from sources across the universe, but because gravity is so much weaker than the other fundamental forces of nature—electromagnetism, for instance, or the interactions that bind an atom together—we never sense them. Einstein thought it highly unlikely that they would ever be detected. He twice declared them nonexistent, reversing and then re-reversing his own prediction.)

P-Value Refresher:

When you get results in a hypothesis test, here's a good question to ask:

"What are explanations for these results?"

1) We got the observed difference due to random chance alone.
   (i.e. the treatment does not help)

   THIS IS THE P-VALUE!

   For example, assume a hypothesis test with hypotheses: $H_O : \mu = 5$, $H_A : \mu > 5$, and $\bar{x} = 5.2$

   In symbols, the p-value is $P(\bar{x} \geq 5.2 \mid \mu = 5)$

   If this probability is low, then we believe that "chance" is not a good explanation for the results we observed. If this probability is high, then we do not have evidence against chance (or evidence for the alternative explanation).

2) We got the observed difference because the treatment actually does help.

3) We got the difference b/c of some lurking (i.e. unmeasured) variable associated with treatment and response.

   It is this possibility that we try to ameliorate with random assignment, large n's, and blocking.