The Ancient Greeks were the first to theorize about atoms. These philosophers believed that setting up an experiment was a perversion of nature, and that the truth could be found through conversation and reasoning.

In approximately 450 B.C.E., Leucippus and his student, Democritus, reasoned that one could cut a block of silver or gold into smaller and smaller pieces. They thought that there must be a point at which the piece of metal could not be cut any further. You would then have the smallest possible piece of that metal. They called this smallest particle \textit{atomos}, or atom, which means “without division”.

Advances in the field of chemistry in the 1700’s made a new look at the atom possible. In 1803, English chemist and schoolteacher John Dalton put forward the first atomic theory. In it he proposed the following ideas about the atom:

1. Elements are composed of individual atoms.
2. Atoms of the same element have the same mass.
3. Atoms can be changed from one element to another.
4. Compounds are formed by joining two or more different atoms.
5. Atoms of different elements have different masses.

In 1897, English physicist J. J. Thomson (1856-1940) discovered negative particles that became known as electrons. These negative particles had a mass a thousand times less than the mass of hydrogen, the lightest atom known. Thomson proposed that these particles were small pieces of atoms. Thomson knew that atoms were electrically neutral, so he proposed that atoms were like “Plum Pudding”. In Thomson’s “Plum Pudding” model an atom was composed of a positively charged electric field (the pudding) with chunks of negative charges or electrons (the raisins) scattered throughout. His model stated that the atom was made up of mostly empty space with its mass being due to the electrons.
A few times each century, a scientist conducts an experiment that forever changes the way we see our world. Ernest Rutherford (1871-1937) and his team conducted just such an experiment in 1910. The experimental apparatus was set up so that a stream of alpha particles from a source of radioactive material was directed at an extremely thin gold foil sheet. Alpha particles are really helium atoms with the electrons stripped off, and are commonly emitted during radioactive decay. Phosphorescent plates were lined up around the gold foil target in order to record the impacts from these particles after they had pierced the metal. Rutherford predicted that the alpha stream would be deflected slightly as it passed through the gold foil. An alpha particle has a mass 7300 times that of an electron, any collision between the two would only move the alpha particle slightly off its original course.

However, the experiment yielded quite different results than Rutherford had predicted. Most alpha particles passed through the foil as if it wasn’t even there. However, some of the particles were deflected at large angles. A few particles were back scattered, which means they were deflected at an angle greater than 90 degrees. The researchers were astounded. If the body of the atom was a positively charged electric field than the deflection off of the electrons should not have been this great. As Rutherford said, “It was almost as incredible as if you fired a fifteen-inch cannon shell at a piece of tissue paper and it came back and hit you.”

Rutherford postulated that Thomson’s Plum Pudding model must be wrong. He proposed that the atom is mostly empty space with all of the mass concentrated in a tiny nugget at the center. The electrons orbit around this nugget in much the same way that planets orbit the sun. This model would account for why the vast majority of the alpha particles passed through the foil undisturbed; while once in a great while an alpha particle will collide with this concentrated central mass and is deflected wildly. Rutherford calculated that to create this type of scattering, the positively charged center, or nucleus, would have to be 10,000 times smaller than the diameter of the entire atom. Another way of thinking of this is that if an atom were the size of a typical football stadium, the diameter of the nucleus would be equivalent to the thickness of a paperclip wire placed at the center of the 50-yard line.
At the end of the 1800’s scientists found that if a high voltage was applied to the ends of a gas-filled tube, a set of spectral lines was produced that were unique to that gas. In this way, gases could be identified by their spectral lines similarly to how a supermarket scanner identifies an item by its unique barcode. In 1913, Danish Physicist Niels Bohr (1885-1962) explained the mystery of the spectral lines with a new model of the atom. He modified the Rutherford planetary model by proposing that only certain electron orbits existed in an atom. If an electron jumped from one orbit to another it would emit or absorb electromagnetic radiation. The jumping of electrons from orbit to orbit causes the spectral lines that we see.
There were certain gaps between what was observed in the laboratory and what could be predicted with Bohr’s model. In 1926, Austrian physicist Erwin Schroedinger expanded on Bohr’s ideas by suggesting that four different features, quantum numbers, characterize an electron. These numbers described an electron’s orbit size, angular momentum, magnetic properties, and spin direction, respectively.

Our current view of the atom was rounded out in 1927 by the work of German physicist Werner Heisenberg. The Heisenberg Uncertainty Principle said that it is impossible for us to know the location of an electron at any given time. We do, however, have mathematical guidelines on where it will most probably be found.

So, in the atom we have a tiny nucleus at the center in which nearly all of its mass is packed. In this nucleus we have positively charged protons and uncharged neutrons welded together. Outside the nucleus we have a huge cloud of probability in which the electrons dart about. We can have atoms with up to 118 protons, 175 neutrons, and dozens of electron clouds bulging out from the nucleus into space. Yet, at the same time 100 million of these atoms can sit on the point of a needle.