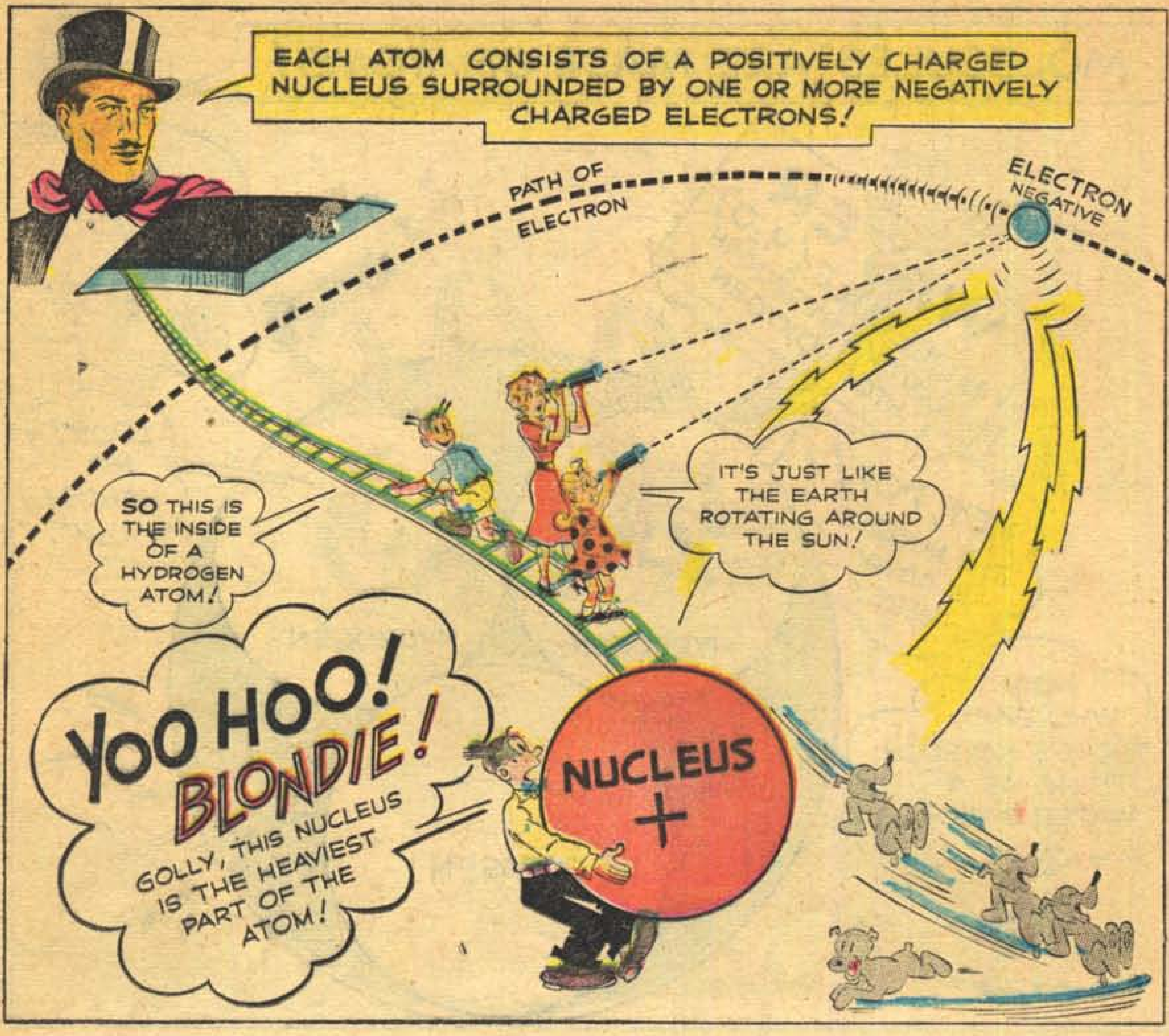


THE ATOM AS A SOLAR SYSTEM

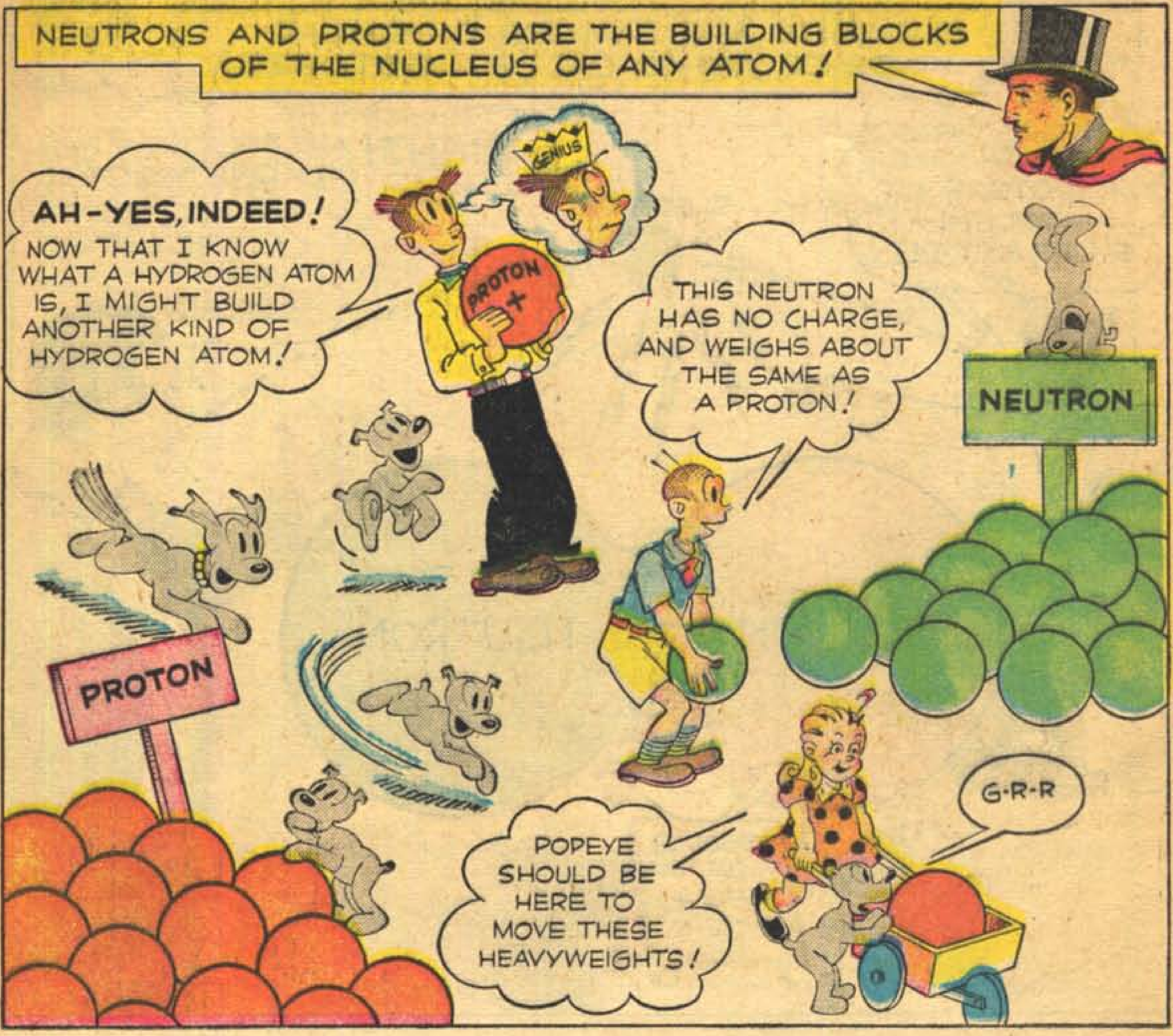
Just about forty years ago many scientists were trying to find out just what an atom is made of and how it is put together. One of these scientists was Professor Nils Bohr of Denmark, another Nobel Prize winner.

Professor Bohr had the idea that an atom is like a tiny solar system in which one or more negatively charged particles called electrons revolve around a positively charged, heavier central nucleus in much the same way that the earth, Venus, Mars and other planets move around the sun. According to this idea, an atom of hydrogen is a nucleus with just one negatively charged particle, an electron, moving around the nucleus just as the earth moves around the sun. Building on this idea, Professor Bohr imagined that atoms of heavier substances were simply made up of a larger number of electrons moving around a central nucleus in which most of the weight of the atoms was located.

Although Professor Bohr's theory has been changed slightly by other scientists during the past twenty years, his main ideas are still respected.

One of the important details of the Bohr theory is that an atom is almost all empty space.

Actually, if an atom were made much larger in all ways until it became as large as the solar system, there would be as much empty space in it as there is in the solar system.



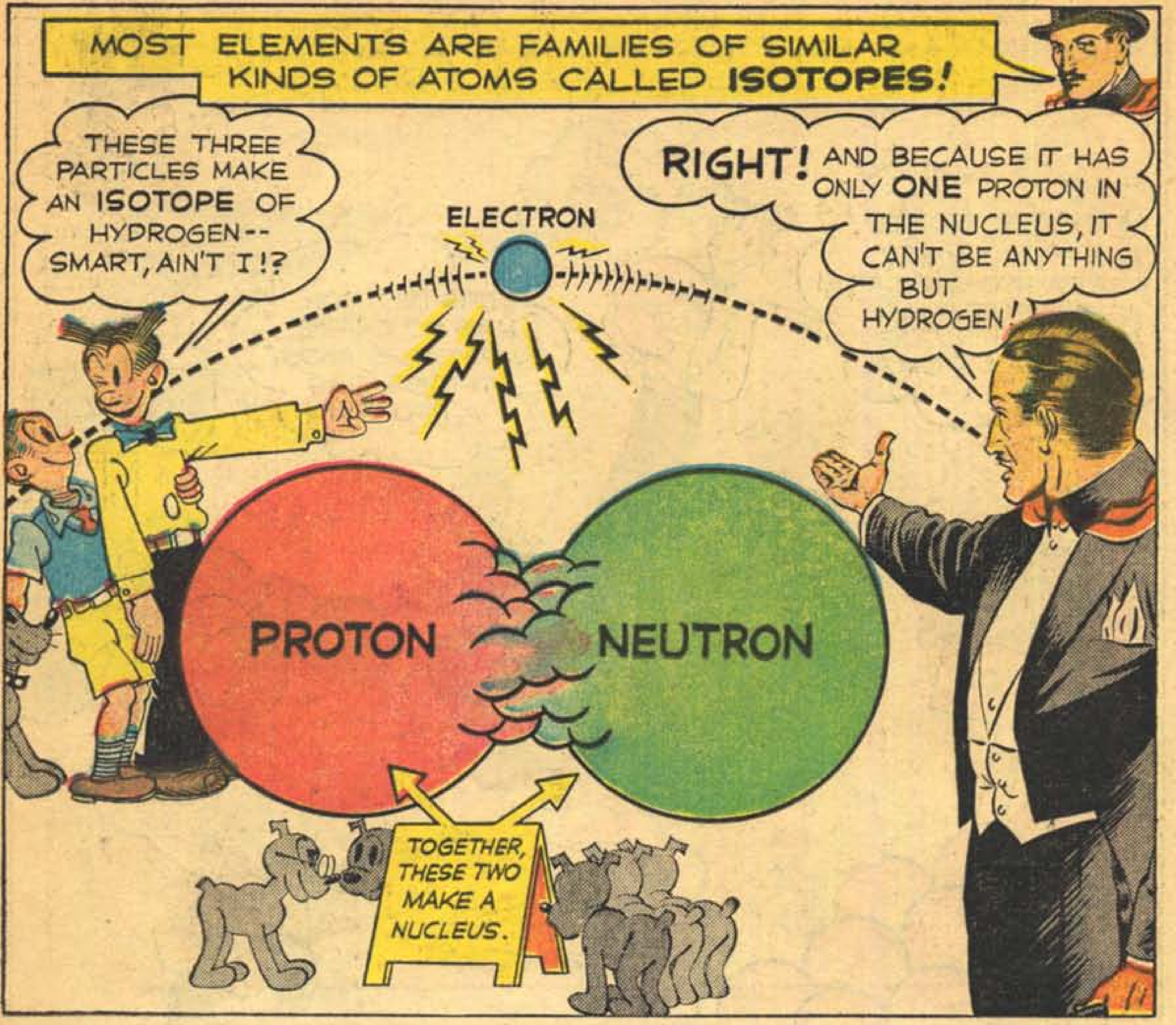
THE WORD "NEUTRON" MEANS NEUTRAL PARTICLE

This tiny particle, which weighs about as much as a hydrogen atom, has no electrical charge. It can be thought of as the nucleus of a hydrogen atom, which has been neutralized.

Because the neutron is neutral, it was not discovered as quickly as the charged particles which scientists learned about. It was identified only about fifteen years ago by Chadwick, an Englishman.

When a neutron comes close to another neutron or even close to an electrically charged particle, it is neither repelled nor attracted unless it gets extremely close to the other particle. For this reason the neutron is quite penetrating. It can easily pass through the outer part of most atoms. It can also penetrate the nucleus of an atom quite readily.

The "proton" is just the nucleus of the ordinary hydrogen atom. It takes about one billion-billion-billion protons to weigh one pound. Each proton is charged positively with the same amount of charge that the negative electron has, though the electron weighs only about 1/2000th as much as a proton.

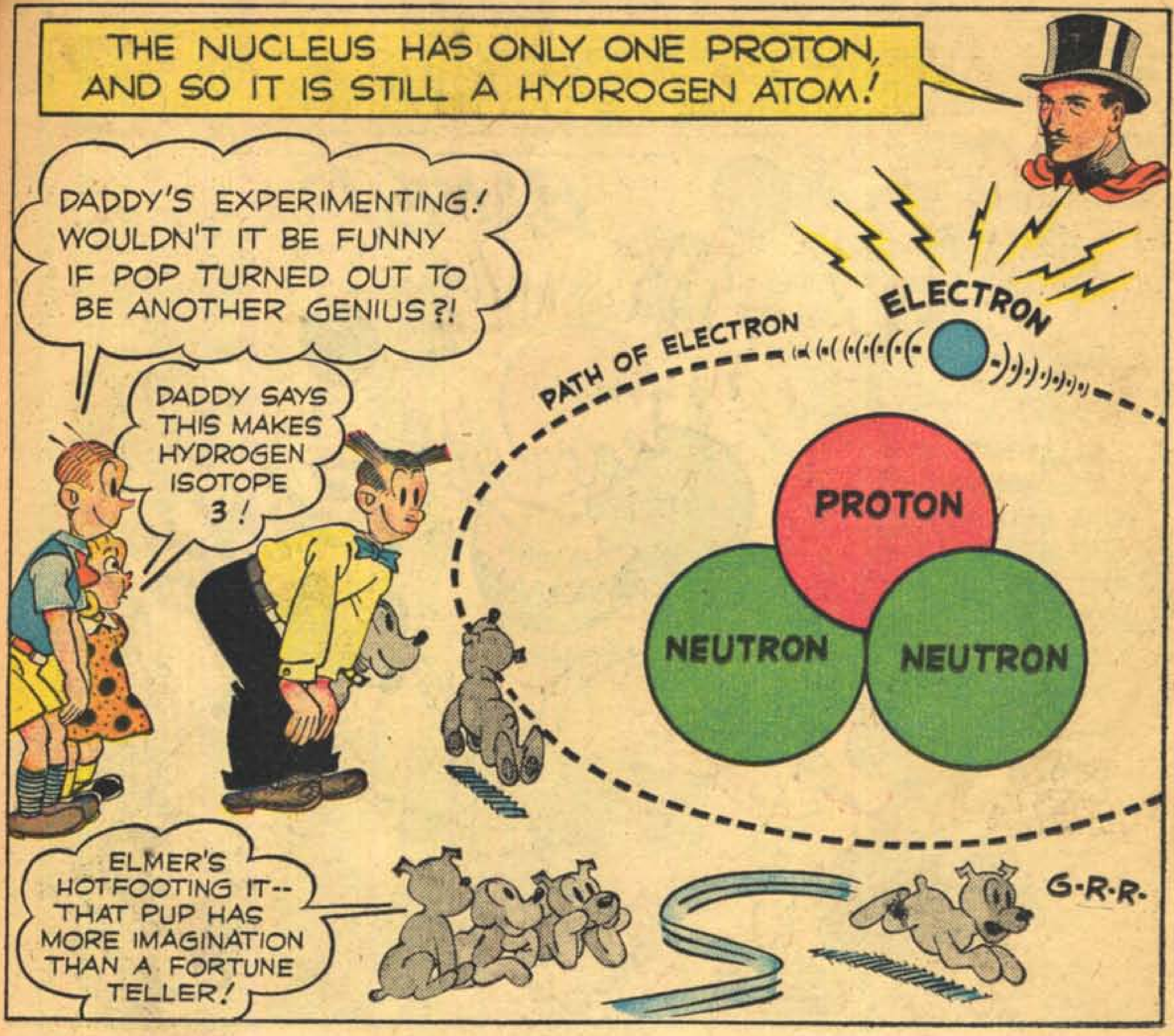


ARE ATOMS OF THE SAME SUBSTANCE IDENTICAL?

It wasn't until 1907 that J. J. Thomson found that an element like mercury consisted of atoms which were alike in every respect except their mass. Thomson was able to show that this was true by putting an electrical charge on atoms like mercury and then making them pass through a magnetic field. What he did is very much like putting milk through a cream separator. When the separator is turned, the heavier part of the milk is thrown outward while the lighter cream is collected toward the center. Thomson found that when he made the electrically charged mercury atoms, called mercury ions, move into a magnetic field, all the ions moved in circles. But the heavier ones moved in big circles, while the lighter ones moved in paths closer to the center.

This kind of apparatus on a much larger scale was used during the war to separate atoms of uranium 235 from those of uranium 238.

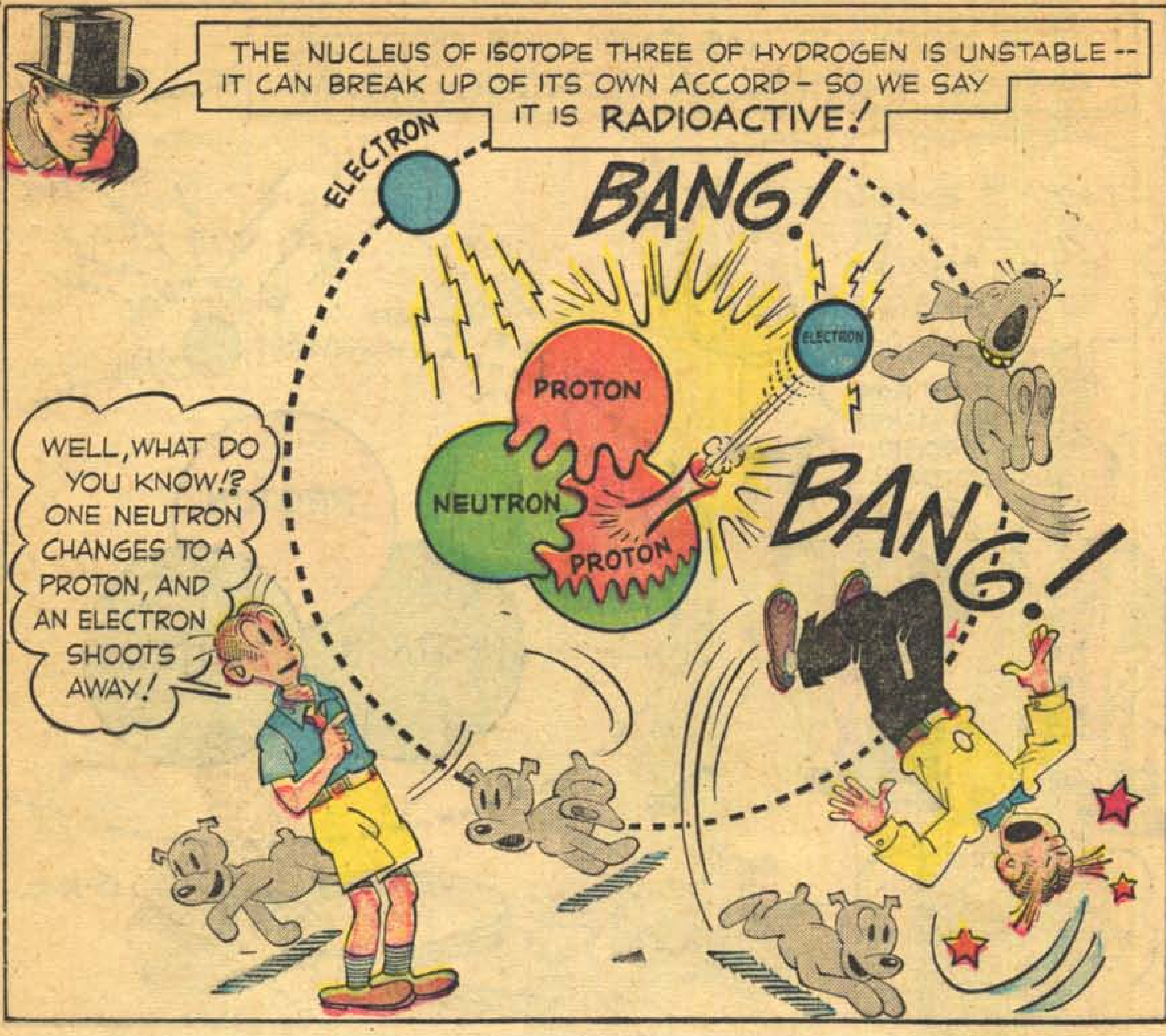
A second method for separating these isotopes, also used during the war, is called the thermal diffusion process. This method is based on the fact that when a substance is heated, the speeds of heavier molecules are less than the speeds of lighter ones. The apparatus used is a container, of which one part can be heated and another kept cold. If unseparated uranium is placed in the hot part, the lighter uranium atoms, are speeded up more than the heavy ones and thus more quickly reach the cold part, where they are removed.



PRODUCING A NEW ELEMENT!

Actually, the scientist cannot build up elements in exactly the same way as Dagwood. But the scientist is able to do almost the same thing as Dagwood, by means of cyclotrons and Van der Graf generators. What these machines do is to speed up electrified particles until they have very great speeds and to allow these speeding particles to hit a substance. When this is done, a speeding particle frequently enters the nucleus of an atom and changes not only its mass but also its electrical charge. In this way an atom of a new element is produced.

In 1919, Ernest Rutherford, the famous British scientist, first performed an experiment of this kind. He did not have cyclotrons or Van der Graf generators to work with. In his famous experiment he used speeding alpha particles as atomic bullets. An alpha particle is the nucleus of a helium atom, and is shot out from a natural radioactive substance like radium. Rutherford allowed his speeding alpha particles to fall on nitrogen atoms. He deduced that the alpha particles entered the nucleus of the nitrogen atoms and produced a new element, for he found protons.

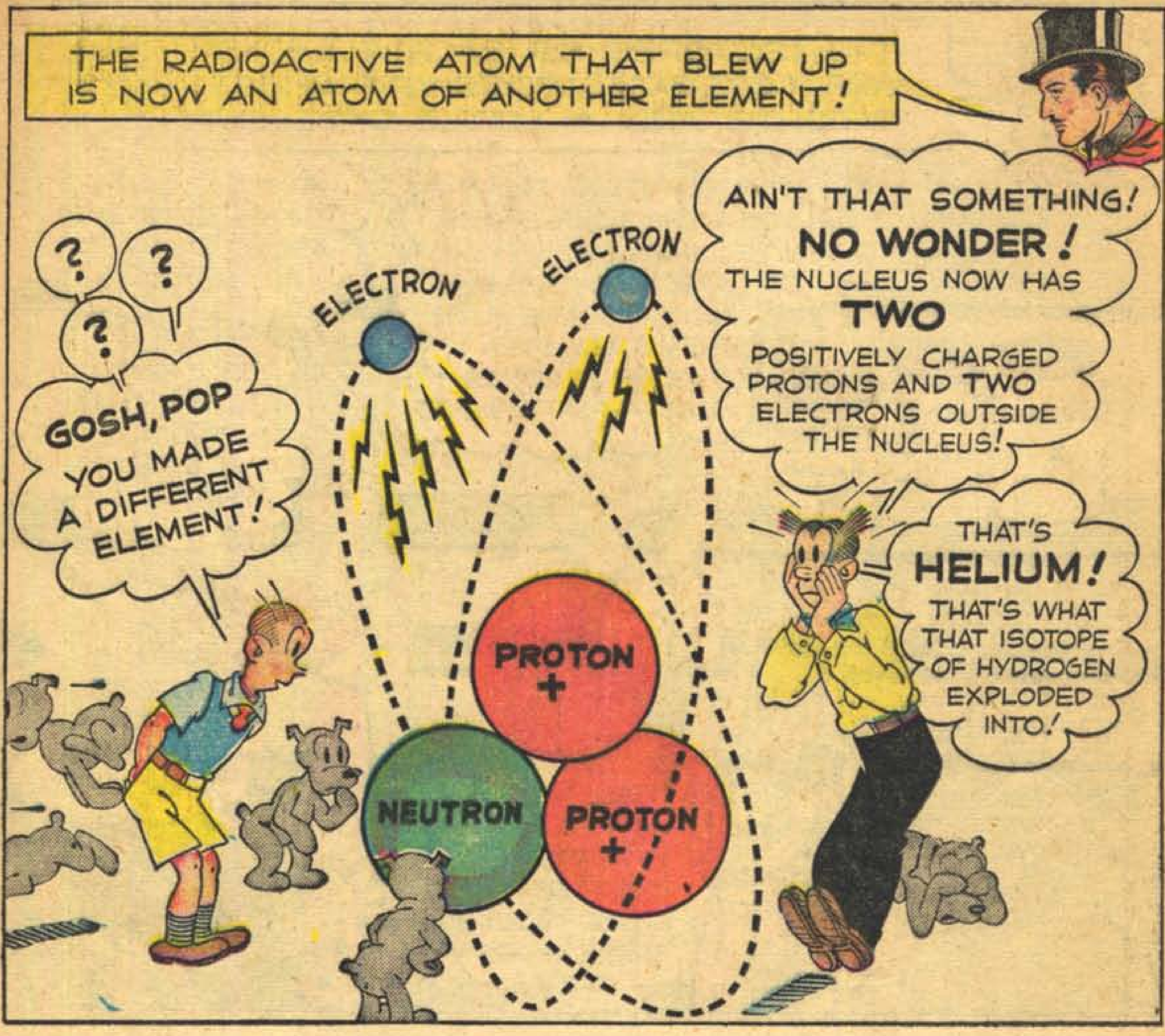


DETECTING RADIOACTIVE ATOMS!

If you visit the Memorial Hospital in New York City, you find biologists and other scientists working with a strange new gadget called a Geiger counter—a detector of radioactivity. Often this device, about as big as a radio tube, has a thin window on one end. Wires from the counter go to an electrical control box with a loud speaker and a counter like an automobile speedometer. When a single speeding electrical particle, such as a proton or a high-energy light ray, passes through the window of the Geiger counter, a click can be heard in the loud speaker or the counter registers one notch.

The Geiger counter is used to detect single atoms of a radioactive substance. Such radioactive atoms are called tagged atoms because they tell where they are when they explode and send out an electrified particle or a gamma ray.

Doctors, by using the Geiger counter, are finding out many new things about how chemicals go to different parts of the body through the circulatory system, for with the Geiger counter they can actually follow the path of the tagged atoms by trailing their explosions.



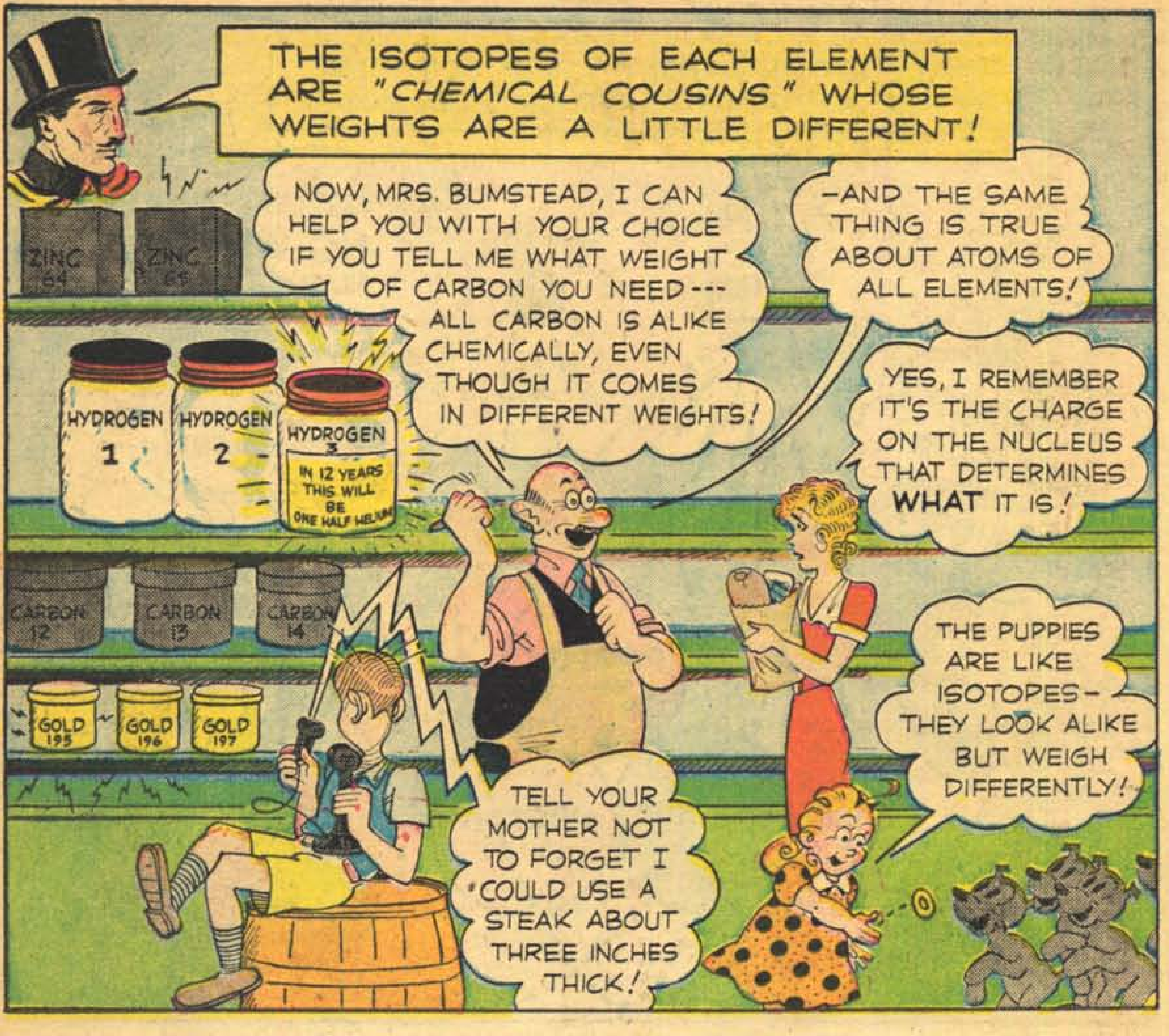
SOME ATOMS ARE STABLE!

Dagwood probably doesn't know it, but he's pretty safe as long as he stays around helium atoms.

The reason is that when a radioactive substance sends out particles and breaks up into an atom of another element, this new atom tends to be more stable than the original radioactive atom. This is true even though the new atom also is radioactive. The process is quite like that of water running downhill, which in the process may give up its energy to a water wheel. In much the same way, when a radioactive atom explodes, the speeding particles which are hurled out of its nucleus take energy from it, and the new atom has less energy than the original atom.

Although a radioactive atom which explodes may form a new and somewhat more stable radioactive atom, eventually a point is reached in this radioactive process where a really stable atom is produced.

For relatively light radioactive atoms, helium is one of the "stopping points." Dagwood need not fear the helium atom—because it will not blow up in his face.



MANUFACTURING ISOTOPES!

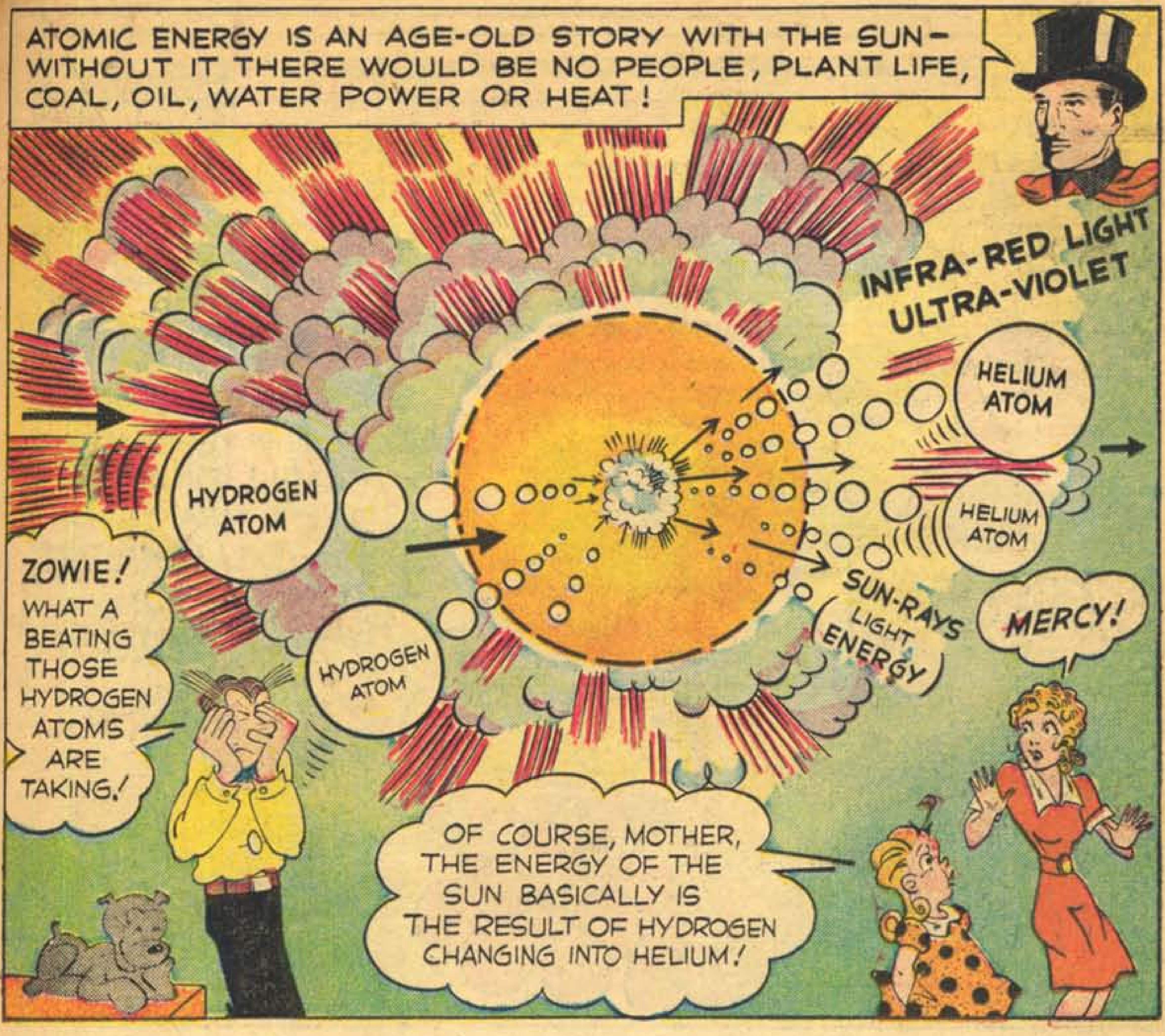
The Oak Ridge plant is literally a radioactive grocery store. An order placed there for a quantity of a radioactive isotope can be filled from stock. Each such order, however, has to be wrapped in a special lead container, so that people handling the radioactive isotopes are protected from the radiation which is given off.

Before the huge atomic energy plants were built at Oak Ridge, Tennessee, and at Hanford, Washington, scientists knew about a number of radioactive isotopes. But even for those that they knew about, the amount of any of these substances they had to work with was pitifully small—so small that a radioactive isotope was just a scientific curiosity.

Now, with these two huge plants, many more radioactive isotopes are known and their production is practically on an assembly-line basis.

The first shipment of radioactive isotopes for peacetime use was made from the Oak Ridge plant of the United States Atomic Energy Commission on August 2, 1946. More than one hundred different radioactive isotopes from the Oak Ridge plant are available to universities, industries and hospitals for use in intensive scientific studies.

Also, the cost of radioactive isotopes has been greatly reduced. A unit of radioactive carbon which cost one million dollars before the Oak Ridge plant was constructed, now costs about fifty dollars.

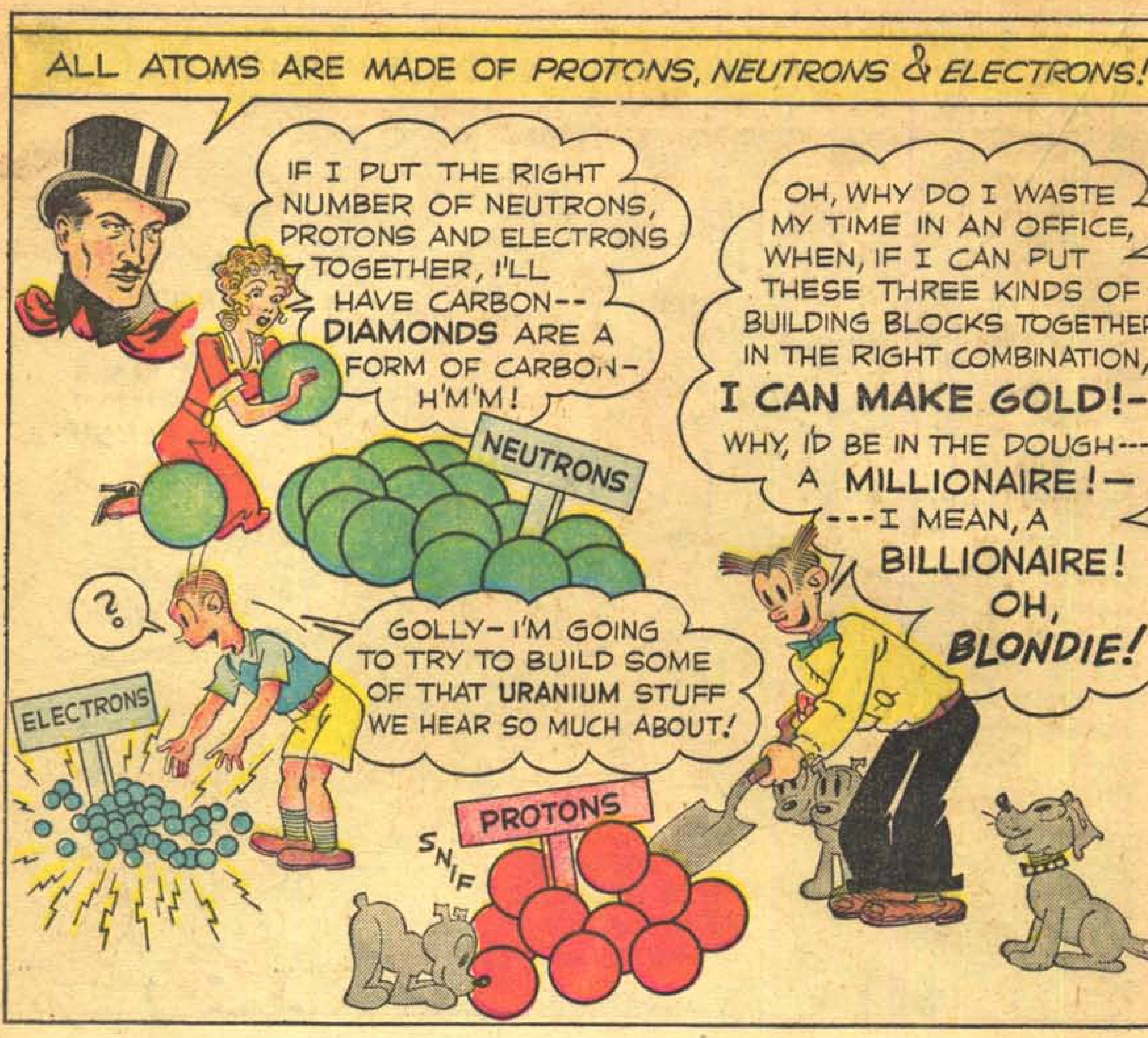


ATOMIC ENERGY IN THE SUN!

For many, many years scientists have been puzzled by the problem of what keeps the sun hot. Many different theories have been offered, but none has explained the very great length of time that the sun has been radiating energy.

It is only recently that Professor Bethe, of Cornell University, and other scientists have proposed what seems to be a satisfactory explanation. Based on the fact that there is a tremendous quantity of hydrogen in the sun, a theory has been worked out which pictures hydrogen in the form of protons (nuclei of the hydrogen atom) as bombarding carbon atoms deep within the sun. This bombardment is believed to change the carbon into an isotope of carbon, which in turn is again bombarded by protons. This second bombardment produces an isotope of nitrogen. After two more bombardments the final result is the original carbon atom and helium. What this total process adds up to is that hydrogen is converted into helium. The number of carbon and nitrogen atoms present is unchanged. These atoms have only to be there to make the process go on. Hydrogen is the atomic fuel which, when converted to helium, produces energy at all the stages in the process, and this energy is eventually radiated from the surface of the sun in the form of light and heat.

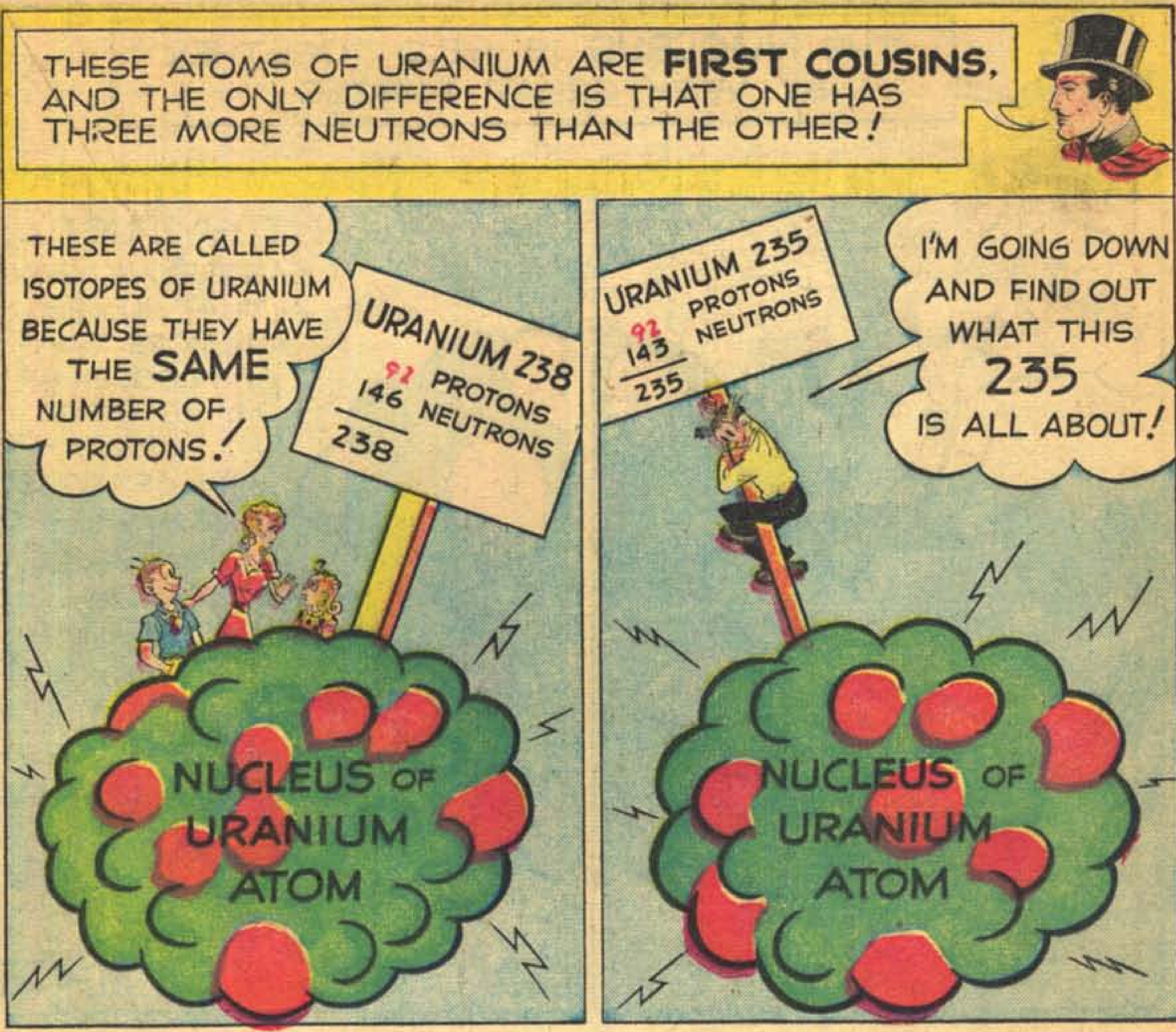
Calculations made by scientists show that the amount of hydrogen in the sun—and indeed in other stars in our universe—is enough to keep stars like our sun shining for several billions of years.



A NEW KIND OF CHEMISTRY

Ever since man discovered that he could make two substances react chemically, he has had the dream of making precious substances from cheap ones—of making gold, for instance, from a base metal. In one sense the modern scientist has made the old alchemists' dream come true. The scientist of today can make gold from other elements. He calls this process the transmutation of one element into another.

Actually, though, the cost of such a transmutation, at present, even with modern apparatus, is such that it is cheaper to get gold the hard way by prospecting and mining. The reason is that the transmutation of an element by modern methods is a process of hurling an individual particle such as a proton into the nucleus of another atom. Such speeding particles are obtained either by a cyclotron or by a Van der Graf generator. In this process the number of hits by the speeding particles is far less than the number of misses. Therefore, the process is very expensive. Many scientists believe, however, that the use of neutrons will tell a different story. These atomic bullets in an atomic pile (see p. 25) have been found to produce large quantities of synthetic elements.

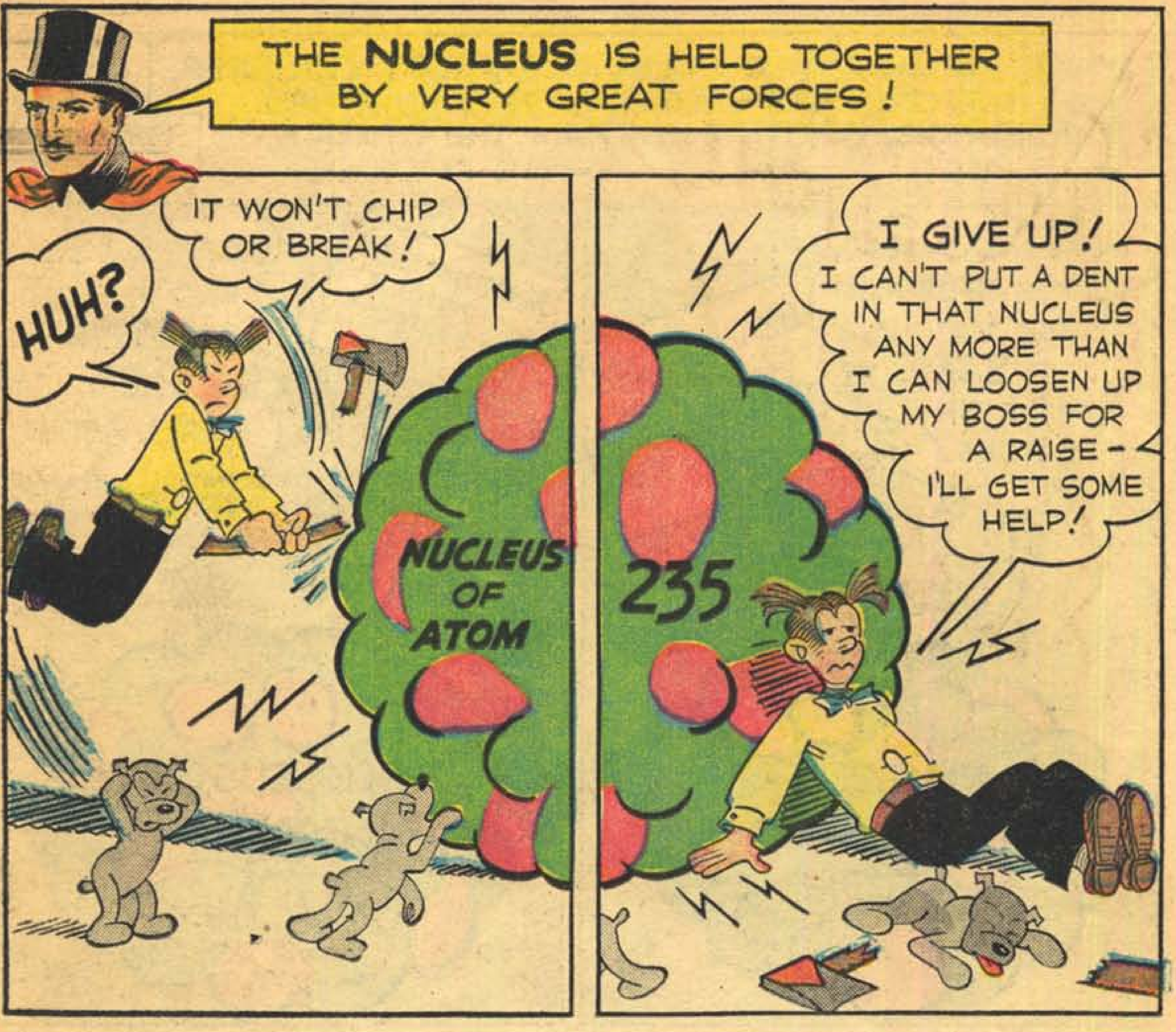


WHAT IS URANIUM?

The element uranium is known to be present in more than one hundred different minerals. In only two of these minerals, pitchblende and carnotite, is uranium present to any great extent. The mineral pitchblende, a dark-brown, sometimes black, ore is found in Germany, the Belgian Congo in Africa, and the Great Bear region of northern Canada. Carnotite, the other major mineral source of uranium, is found as a bright, yellow streak in sandstone. It has been discovered in Utah, Arizona, and Colorado.

Because of the importance of uranium in atomic energy work, an intensive search for pitchblende and carnotite has been under way during the last ten years and has revealed deposits of these minerals in other parts of the earth. It is difficult, however, to state where rich deposits have been found, because each nation today is guarding such information as it guards a military secret.

Until the discovery of the importance of uranium for atomic energy purposes, the need for this element was very small, mainly as a coloring substance in glass and pottery.



MYSTERIOUS FORCE HOLDS NUCLEUS TOGETHER

The proton and neutron are very much smaller than the atom as a whole. In fact, if the atom were as large as a room, the nucleus in the center would be smaller than a pea.

The protons and neutrons making the nucleus of any atom seem to be packed very closely together. This means that there is much less empty space between these particles in the nucleus than there is in the region outside where the electron is located. This fact is important, for it compels scientists to think of new and different kinds of forces as holding the nucleus together. The forces which scientists already know about would tend to make the protons, being charged alike, repel each other with tremendous forces at extremely small distances, and this would cause the nucleus to fly apart. Therefore, a new and more powerful force, different from any that scientists have identified, must be acting on the particles of the nucleus in order to hold them together.

WHY CAN'T DAGWOOD SPLIT THE NUCLEUS?

Trying to split or penetrate the nucleus of an atom is again like trying to make hair stay in place when it has been combed on a cool, dry day. Dagwood is using a crowbar. But the crowbar consists of atoms, and each atom has a nucleus. When the end of Dagwood's crowbar is brought very near the uranium nucleus, there is a force of repulsion on the bar because the uranium nucleus and the nuclei of the atoms in the end of the bar are close together—and the closer they get, the greater is the force of repulsion.

Scientists have the same trouble that Dagwood has in attempting to penetrate the nucleus. What they have to do, to get anything inside the nucleus, is to use speeding particles. Often they use speeding electrified particles. If they do, each speeding particle must be moving so fast that the repulsion on it, from the nucleus, will not stop the particle before it gets inside the nucleus. The particle must actually be moving thousands of miles per second in order to penetrate the nucleus.

Such speeding particles are often obtained by means of the cyclotron, in which the electrified particle gets its speed by being whirled many times in a spiral path. This action is very much like that which the hammer thrower uses in getting the hammer up to speed.