CAN YOU

# Believe it?

WITH ASSOCIATE PROFESSOR DEREK LEINWEBER

# Striving for gold

TURNING lead into gold: it's been the dream of alchemists for millenniums. It conjures images of mystics poring over glowing cauldrons of dangerous, smoking, pungent solutions of mercury, silver, lead and sulphur; hidden away from the prying eyes of greedy believers.

And they had high expectations of success.

Ancient Greek scientist Aristotle believed that all materials in the physical world were made of four elements - water, earth, air and fire. By changing the proportion of these elements, it was thought that one material could be transformed into another.

Ancient Egyptians thought metals grew in the ground, like plants but much more slowly, eventually maturing to gold. They attempted to hurry the growth of these metals through elaborate mixing and heating procedures.

Mankind's fascination with gold is easy to appreciate. It is rare, and its malleable nature makes it easy to shape.

Historically, there was also an astrological connection. It was thought that gold contained the light of the sun.

But, most importantly, it does not tarnish like copper or silver or rust like iron. These practical properties make gold valuable to today's hi-tech industries, including satellite manufacture and high-end audio-visual equipment.

But were the alchemists successful in transmuting lead into gold?

Alchemists were quite certain that they had done so. If a metal looked like gold and felt like gold, as far as they were concerned, it was gold.

But we can say with absolute certainty that the alchemists never realised their dream.

The properties of the elements are all governed by the manner in which the cloud of electrons that surrounds the nucleus of the atom arrange themselves. As electrons are shared between neighbouring atoms, chemical bonds are broken and re-formed, making it possible to build enormous complex structures like DNA.

But to change one element like lead into another like gold, one has to change the number of electrons in the atom. And the only way to do that is to change the structure of the nucleus, at the heart of the atom.

No chemical means can do that.

So has lead ever been transmuted into gold?

The answer is yes. But it is only within the past 100 years that the secret was revealed.

Nuclear physicists discovered that the nucleus is composed of positively charged protons and neutrally charged neutrons. In an electrically neutral atom, the number of electrons is equal to the number of protons. If you want to change the number of electrons, you need only change the number of protons in the nucleus. Since lead has 82 protons and gold has 79, three protons must be removed from lead's nucleus. These might be knocked out by a particle accelerator or transmuted into neutrons through the capture of a high-energy electron.

The downside is that this gold would be radioactively unstable, eventually decaying to other elements. And because lead is stable, forcing it to release three protons requires a vast input of energy. Indeed, the cost of transmuting it greatly surpasses the value of the resulting gold.

But it has been done. In 1972, Soviet physicists in Siberia reported the appearance of gold in the lead shielding of an experimental reactor.

Today, particle accelerators routinely transmute elements. Particles in the beam impact a target material, knocking protons and neutrons free and creating new elements.

And nuclear reactors release energy by transmuting heavy elements into lighter elements. Such nuclear reactions are used to produce americium-241 for use in household smoke detectors and technetium-99 for use as a tracer in health care.

Indeed, the nuclear industry could be considered to be a form of alchemy, as it utilises elemental transmutations on a daily basis.

But the people working in this industry do prefer to be called physicists.

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## Changing times