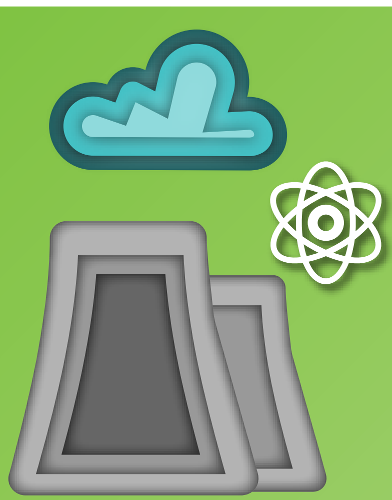
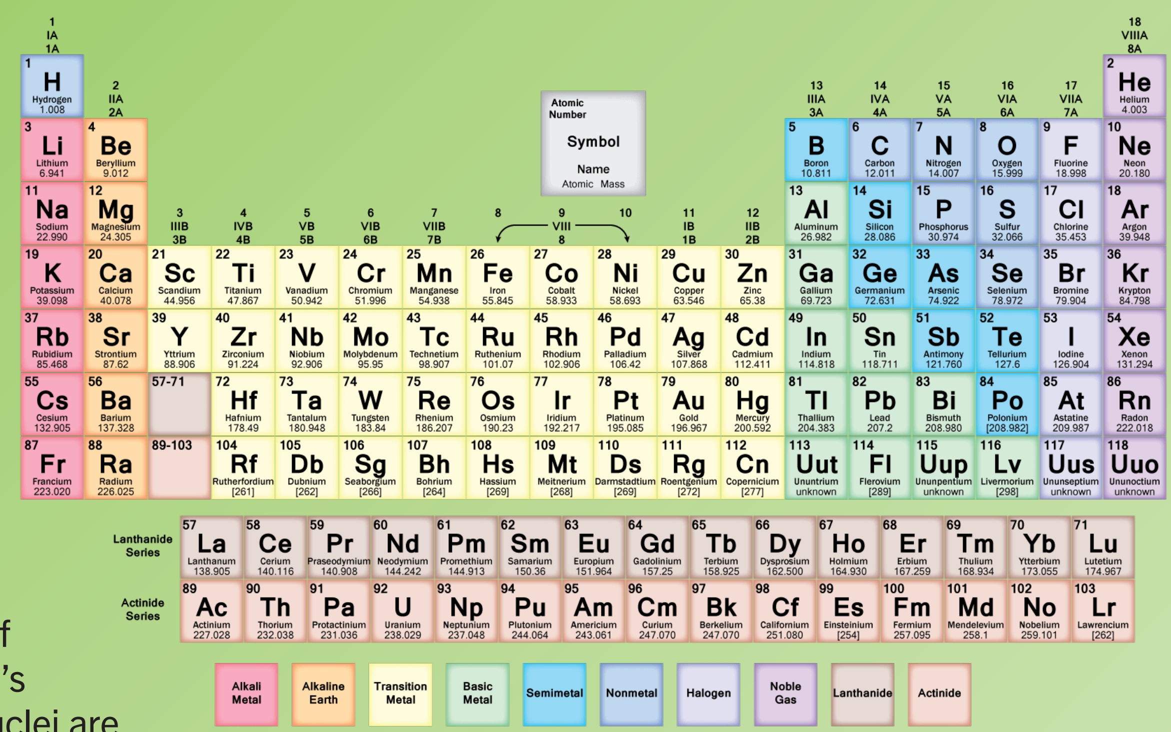


NUCLEAR POWER

THE BIG IDEA

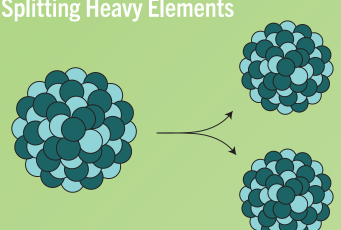
Both nuclear fission and nuclear fusion are centered around the fundamental principle that certain atoms release tremendous amounts of energy when they split (fission) and others when they combine (fusion).



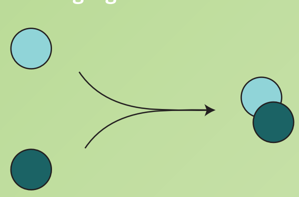
The key is how tightly the protons and neutrons are held together in the nucleus of the atom (the "binding energy" of the atom's nucleus). The most tightly bound atomic nuclei are nickel (28 protons in the nucleus) or iron (26 protons), which occur near the middle of the periodic table with lighter atoms towards the front of the periodic table and heavier atoms towards the end. Recall that the atoms (or elements) on the periodic table are organized by atomic number (the number of protons in the nucleus), which gives you a sense of their atomic mass (higher number, higher mass).

We can release energy by splitting very heavy nuclei (like uranium, 92 protons) from an atom of lower binding energy (the uranium atom) into atoms of higher binding energy (such as barium and krypton atoms). Similarly, we can release energy by merging very light nuclei (like hydrogen, 1 proton) from atoms of lower binding energy (the four hydrogen atoms) into an atom of higher binding energy (such as a helium atom). Either method will shift the atoms into a more tightly bound state (i.e., closer to configuration seen in nickel or iron), thereby releasing energy. Counterintuitively, the tighter bind results in less mass, and less mass results in energy release. This is the magic behind Einstein's famous equation: energy equals mass times the speed of light squared (E=MC2).

Nuclear Fission
Splitting Heavy Elements



Nuclear Fusion
Combining Light Elements



In simple terms, the equation implies that energy and mass (matter) are interchangeable.

THE BIG CHALLENGE

Nuclear energy first became a power source over six decades ago in the form of nuclear fission. To date, scientists have been unable to achieve nuclear fusion even though our Sun does it constantly (converting hydrogen into helium and releasing tremendous amounts of energy in the process). Nuclear fusion is so hard because there is a strong electrostatic force between nuclei that prevent them from getting close enough to collide and fuse. The Sun can overcome this repulsive force through incredibly high temperature (over 18 million degrees Fahrenheit) and its immense gravity that creates extreme pressure. Without that immense gravity, here on Earth we need ten times the temperature required on the Sun to create the conditions for nuclear fusion. In March of 2022, Oxford-based UK tech firm Tokamak Energy reached a milestone in privately-funded fusion research after its tokamak reactor reached 180 million degrees Fahrenheit; a first ever.

SUSTAINABLE ENERGY FOR THE FUTURE

Both nuclear fission and nuclear fusion can create zero-emission energy for the world's consumption, but only nuclear fusion can create zero-emission, renewable energy. Nuclear fission is technically non-renewable, because nuclear power plants usually use a very rare type of uranium (U-235), which is a non-renewable resource. Nuclear fusion holds the key to near-infinite, renewable, emissions-free power. In the meantime, the world can benefit greatly from dispelling the myths surrounding nuclear fission and employing it more broadly to power our world.

LET'S BUILD R AND S SUSTAINABLY

EARTH WEEK: APRIL 18-22, 2022

Presented by the R&S Sustainability Committee