LEGO Chart of Nuclides

Demo instructions

Thanks for volunteering! This demo (courtesy of JINA) is a pretty simple way to show people what makes elements and isotopes different and why they are stable or unstable. You'll need some or all of the following equipment (provided by Zach Constan, outreach coordinator):

Figure 1. The completed LEGO Chart.

- 2 Large grey baseplates with proton/neutron numbers
- 1 Large grey baseplate with tiles for each isotope
- 8 bins of 2x4 bricks in 6 colors, plus two tan plates to build on and many orange brick separators

Before the demo

On one table, set out the eight bins with labels facing the guests and open them up. On another table, place the two large baseplates with proton/neutron numbers so that the neon row is towards the guests. Also include the large baseplate with isotope tiles and isotope legend poster (in plastic stand).

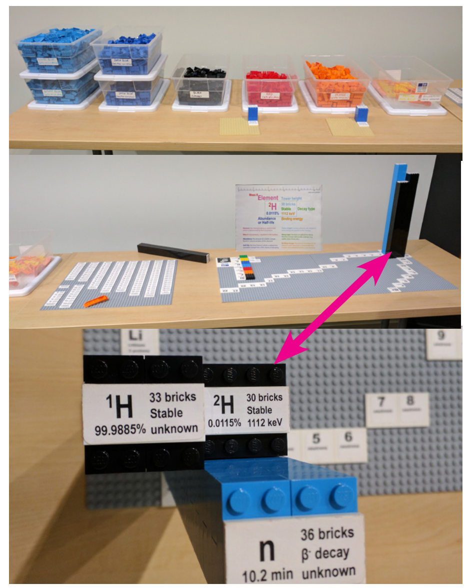

Figure 2. Initial two-table setup.

Build three towers to start: H-1 and H-2 in black, n (neutron) in light blue. Each tower is 30 or more bricks high with each level being two 2x4 bricks side-by-side, alternating directions (see the example towers on the small tan building plates) with isotope tiles on top. Place them on the chart plates.
Also build FOUR He-4 towers in black an set them aside. These will serve as a useful explanation of binding energy.

This demo works best with two volunteers - one to help kids with building while the other helps place isotope towers and explain the Chart.

If you expect to have a large volume of visitors, spread things out so many people can access the bricks and plates.

During the demo

Show them the extra hydrogen-1 tower in your hand. *Just like this tower is made of smaller LEGO bricks, you and me and all the stuff in our world are made of smaller pieces; tiny little particles called atoms. The atom is made of even smaller pieces – it has a central core called the nucleus which is made of protons and neutrons. That's what NSCL scientists at MSU study!*

The kind of nucleus (and thus atom) you have depends on how many of each: the number of protons tells you what element it is, and the number of neutrons tells you what isotope it is.

Point to the "H" symbol on the tile. *This tile on the top of the tower lists just that information: the element is H (hydrogen), which has one proton. It also shows the isotope is 1, so the total protons + neutrons is 1, so zero neutrons. This hydrogen-1 tower is 33 bricks high, which relates to the **extra energy per particle** in that nucleus. It is also a stable type (meaning it exists forever), so we use black bricks* (point to the labels on the sides of the bins). *(OVER →)*

If there are lots of visitors, you can give the introduction to many at once and then hand out tiles to all. There should be room for 4-5 people to build at the same time.

If a kid wants to do it again, and there's a line, just send them to the back. They're usually happy to!

Keeping count of the number of layers you've built is hard - use the "LEGO ruler" on the legend poster!

During the demo con't

Now you can build a tower for a different type of nucleus!

Use the orange brick separator to remove one isotope tile and give it to the guest – start with all stable ones (isotope tiles with black tiles next to them), then add adjacent isotopes moving out)

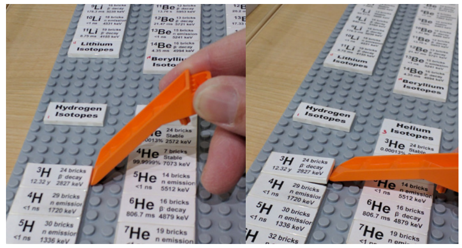

Figure 3. Removing an isotope tile.

What color of bricks do you need? How many layers do you need to build? To make it strong, build each layer in alternating directions! Then put your tile on the top. (It should be centered vertically - help them if necessary)

Once they've built their tower, help them find where it goes. *This is called the chart of nuclides – every type of nucleus has its own spot on here. You place it by finding the element row, and the number of neutrons is the isotope number minus proton number* (they can do it, or you can to make it simpler).

When you put it here, you can tell how that nucleus is different from the others. Humans have discovered over 3000 isotopes so far! Not only does it have a different number of protons and neutrons, but it might be stable or radioactive (meaning it only exists for some time and then changes, trying to become stable), and it probably has a different amount of energy (height). Our researchers at NSCL measure the differences between nuclei.

Scientists in the Joint Institute for Nuclear Astrophysics use new discoveries to understand how stars work! Want to see what makes a star shine?

- *Stars like our sun combine four hydrogen-1* (show the tower on the chart) *to make a helium-4 (after decay).*
- (Stack the 4 helium-4 towers) *Here's the total extra energy of the helium-4 nucleus that is made. It's less than the extra energy in ONE hydrogen-1, and WAY less than 4 H-1 nuclei! That means a LOT of energy came out and keeps the star shining.*

Want to know more? Have a postcard! (Optional) Point them to the free stuff, most importantly postcards that have the laboratory web address.

Feel free to point out the applications of nuclear science and the economic impact on Michigan. Suggest they can take Zach's card if they want more information, and should email him or check out our website (on the postcard) to find NSCL tours and summer programs.

Don't worry about having to talk with people about the lab... you know more about it that they do!

Stick to the positive messages NSCL wants to convey:

- *We do world-class research (top 3 for rare isotope)*
- *We educate new nuclear scientists (#1 grad program in US)*
- *Our safety record is excellent*
- *We are good for Michigan: high-tech jobs and federal funding*
- *We are awesome*
- *If you're not sure of an answer, it's OK to say "I don't know"*

Some things they may notice, or you can bring up if there aren't people waiting:

- *Nuclei want to be at low energy, which is why some are stable (generally low-energy) and some are radioactive (they will change by releasing some energy)*
- *Notice: the farther you get from the valley of stability, the shorter the half-lives tend to get.*
- *The edges of the chart are unobserved – never discovered!*
- *The "dripline" is where the nuclei start doing proton or neutron decay – it has so much energy that extra protons or neutrons just fall right off the nucleus.*

If you are getting lots of questions and have more people waiting, encourage them to take Zach's card and send email!

Tearing down

Deconstruct all the towers - you can do this by hand or using the orange brick separators - and return the bricks to their appropiate bins. Please arrange all the isotope tiles in their rightful places on the large grey baseplate where they started.

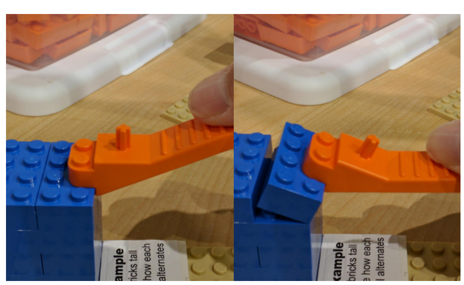

Figure 4. Removing bricks.

