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Presenting the tactile periodic table

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Through the collaboration of two members of the ACS Committee on Chemists with Disabilities, a prototype Braille periodic table has been created. This project is part of a wider goal of making chemistry accessible to all.

Tactile tools are substitutes for visual representations that provide blind and low-vision individuals access to a wide variety of information. Braille labelling in elevators, for example, is essential for orientation and movement. In contrast, accessibility standards for teaching students are less well defined and accommodations often need to be individualized. The vision of the American Chemical Society Committee on Chemists with Disabilities (CWD) is "making chemistry accessible to all". This committee has released an e-book that discusses the tools that can help to break down barriers that exclude those with disabilities from participating fully in science[1].

We met at a conference and teamed up to design and fabricate a prototype Braille periodic table. M.M. is an assistant professor who was diagnosed with macular degeneration and cone-rod dystrophy at the age of seven, resulting in the loss of her vision. M.F. is an analytical development chemist and a woodworker, specializing in the tactile representation of chemical concepts after years of working as a visual assistant at the University of Cincinnati. We combined our expertise and experiences to begin making a tactile periodic table (Fig. 1).

Pooling expertise

As a blind scientist, Mona (M.M.) uses adaptive tools to advance her research and break down barriers that exclude those with disabilities from participating in science. Early in her career, she was drawn towards computational chemistry. This field relies heavily on data analysis and modelling and she realized that these tools could be modified to be nonvisual. Throughout her career, she has compiled all her tools into the Blind Scientist Toolkit[2]. This online repository includes tactile models, accessible software, and strategies for navigating the scientific landscape as a blind individual. For example, she routinely uses the swell-form machine[3] which enables quick and effective analysis of complex scientific data. This tool, along with many others, has enabled her to visualize data in a way that is accessible for blind scientists.

When Michael (M.F.) was a chemistry graduate student, he worked one-on-one with a blind student enrolled in general chemistry. They used the adaptive tool Picture In A Flash (PIAF)[4], which converts images into tactile representations. This is where he became interested in marquetry and woodworking to make more elaborate tactile images. His first tactile carving was a map of the world. To do this, he set up a large drafting table and taped a map to a maple board. Using a fingertip knife, he cut through the map and into the wood, tracing out all the countries. Once the image was transferred onto the board, a rotary tool was used to carve out the tactile image. He then sealed the wood with spray lacquer and painted the carved image black (for the sighted people). Tactile carving evolved into a hobby and the world map was followed by several other works, often related to chemistry, including two tactile periodic tables that would prove to be studies for the Braille project.

Developing the tactile periodic table

CWD debuted an accessible periodic table in 2019[5]. The display had both Braille and sign language for each element. The usual text for the atomic symbols were intentionally left absent to simulate the challenges a person with a disability may encounter in accessing the table. In part because of the size and difficulty in assembling this periodic table, it has not been back to a national meeting.

The idea for the Tactile Periodic Table Project came about at the CWD meeting in 2022. Mona wanted a periodic table for professional use that could be hung and used in her office. The atomic number, symbol and weight would be represented both visually in text and non-visually in Braille. Michael's local ACS section supported the project and bought a jar of 10,000 Raster spheres (1 mm acrylic balls specifically made for Americans with Disabilities Act signage). We developed the process of carving a small indentation into the wood and then using tweezers to place and secure each Raster sphere using epoxy. Example tiles were mailed between us to refine and finalize the approach, leading to a template roughly 3 feet by 2 feet.

The following year, we demonstrated the first trials of the project at the CWD meeting, and the carving process began on the prototype in between sessions. Over the following year, Michael spent about 200 hours carving the prototype Braille periodic table, often at art festivals, professional society meetings and conferences. At one such conference (the May Conference at John Carroll University), Michael gave a lecture about the project after which several students suggested visiting a maker shop called the think[box] at Case Western University[6] and exploring computer numerical control (CNC). CNC technology uses software to control the movement of machine tools. Michael started taking classes at the open-access facility and began considering ways to bring in automation.

As word spread locally, the project caught the attention of Troy Spear at the Computer Assisted Design (CAD) and Engineering Technology program at Kent Roosevelt High School. After showing the engineering students the almost finished prototype, the class appreciated the effort that had gone into hand carving and were confident that their skills and machine could replicate the prototype. The hand-carved Braille periodic table debuted at ACS Spring 2024. During the New Orleans meeting, the CWD and ACS leadership decided to support the project, providing the wood for Mr Spear and his students. In turn, the students were able to carve Mona's template in eight hours using their CNC machine compared to 150 hours when done by hand.

Now that the wood carving was automated, the remaining technical challenge is the placing of the Braille spheres. It takes an average of about 15 minutes per element to add Raster spheres by hand. This works out to about 30 hours to complete all 118 elements for one periodic table. As such, we are actively seeking collaborators and supporters in this space to optimize this process.

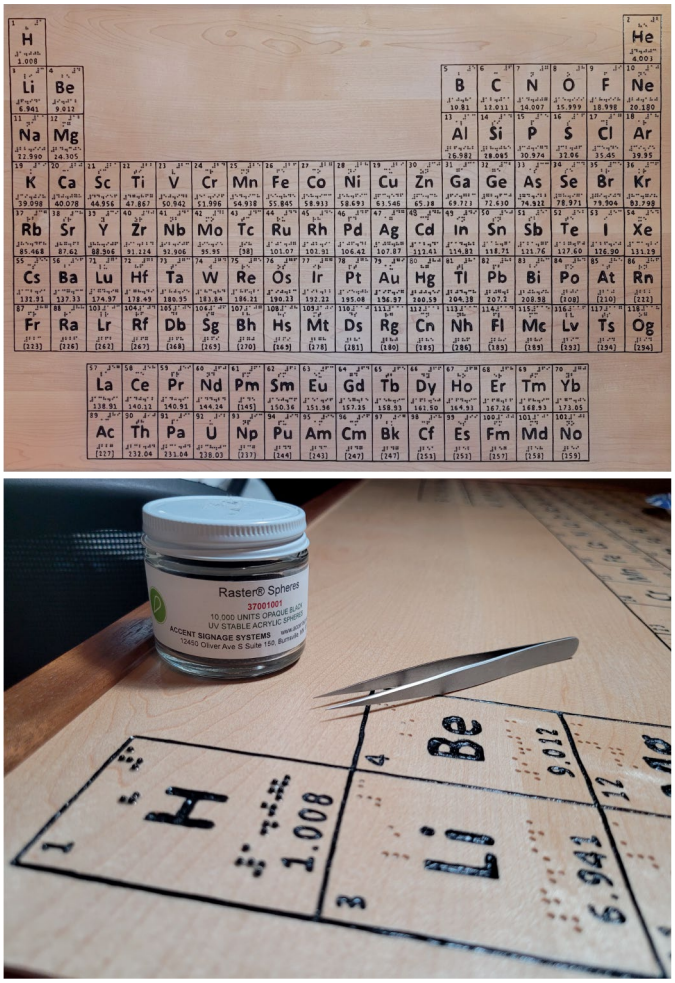

Fig. 1 | The tactile periodic table. The tactile periodic table prototype took 200 hours to make by hand including 15 minutes to add the Braille for each element using the tools shown.

The hand-carved prototype is preparing for a final trip where it will be hung permanently in the Bioengineering Laboratory at Northeastern University. Michael is adding the Braille to the machined-carved prototype and plans on using the Kent Roosevelt CAD design to start a third prototype at the think[box]. We are happy to chat with anyone interested in making their own.

Everyone has the potential to contribute to science if given the right tools. This collaboration has been a testament to the power of these tools in making that potential a reality and demonstrates that blind individuals can be benefactors, not just beneficiaries, of science.

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Competing interests

The authors declare no competing interests.