Work

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K. R. ARARAGI

Geoscientist Hiroto Nagai composed music about Earth's climate system using meteorological data from the polar regions.

SCIENCE FINDS ITS SONG

Turning data into sound and music helps researchers to build community and communicate their science to a broader audience. **By Jane Palmer**

When Colin Campbell stood before colleagues at a chemistry-department gathering last February at the University of Edinburgh, UK, it wasn't to talk science. It was to play science. On his bagpipes. With the tune crafted from the molecular structure of NANOG, the only protein with a name derived from Celtic mythology.

Campbell, a spectroscopist, and a bagpiper in a community band, had started experimenting with translating scientific data into music years earlier — assigning RNA sequences to musical notes and converting spectral lines into melody. What began as a side project to merge his two passions, music and science, soon became a communal enterprise. While on a Fulbright scholarship at the University of Colorado Boulder in 2018, he formed a band with colleagues — the Rocky Canyon and the Flatiron Five — to perform data-driven compositions.

Once back in Edinburgh, Campbell created several data-inspired pieces with colleagues, such as one based on the football-shaped buckminsterfullerene (or buckyball) molecule. Their efforts inspired another colleague at the university, chemist Cecilia Hong, to propose a Data Jam Workshop.

"It creates the first emotional connection that can lead to deeper scientific dialogue."

For this collaborative, data- and music-based event, Hong and co-organizer Joshua Levinsky, a crystallographer also at the University of Edinburgh, invited anyone who wanted to create music about, or from, their science. Some graduate students, postdocs and professors had the coding skills to turn numbers into notes, others arrived with the music-arranging and production skills to turn a cacophony of notes into a coherent musical narrative.

"It brought together people who'd never met before," Hong says. "Their research didn't overlap, but they clicked instantly — just through this shared aim of making music from science."

The Edinburgh jam session is part of a

growing movement of scientists transforming their raw data into sound or music. Some are uncovering new patterns in their findings, others want to increase accessibility for people with limited vision, and many hope to captivate and reach broader audiences. For Campbell, the process of 'musification' has helped to foster a sense of community in the chemistry department and has provided a way for scientists at all careers stages to come together. "Sometimes, scientists just need a reason to connect," he says.

Audio insights

But how does one turn data points into ditties? Campbell's Boulder band usually opened with 'RNaseP', a piece named after a molecular machine that helps cells to make proteins. Initially, Campbell tried mapping the molecule's nucleotide bases directly onto musical notes. "That turned out to be a learning experience," he says. "I didn't get music — I got noise."

The breakthrough came when he mapped the four RNA bases onto a pentatonic, or five-tone, scale. The result sounded promising, until he played it on a piano, which is best suited to conventional, repetitive sequences — not RNA's unruly biology. Switching to a guitar solved the problem, enabling the crafted melody to capture RNA's tangled architecture. Sometimes, Campbell played a loop of the tune in reverse to reflect the molecule's ability to fold back on itself.

Researchers typically use graphs, informatics and imaging techniques to interpret research findings, but sonification — turning data into sound — can offer fresh insights when it comes to analysing data, says Margaret Schedel, a researcher of composition and computer music at Stony Brook University in New York.

Schedel is blind in one eye and uses her finely tuned sense of hearing to perceive depth. A home experiment in 2011 helped her to appreciate that even non-musical researchers can glean insights from audio. For example, Schedel's husband Kevin Yager, a materials scientist at Brookhaven National Laboratory in Upton, New York, probes the structure of matter using X-rays. Schedel began playing around with sonic representations of his data. One caught his ear: a small glitch in the otherwise steady strum alerted him to a misaligned sample.

Schedel's sonification highlighted the error and her husband became convinced that he could use the technique in his lab. Yager and his colleagues make measurements as precise as 1/25,000 of the width of a human hair by aiming an X-ray through 20 pieces of equipment to focus the beam on a sample. If any piece of equipment is out of kilter, they can't collect data properly.

Schedel says that her husband can simply listen to an ambient sonification while working on something else and still quickly detect misalignment errors. Auditory systems outperform sight at detecting regular patterns over time, she says, and ears, unlike eyes, don't have to focus directly on the data to discern fluctuations. The two researchers reported their findings in 2012 (M. Schedel and K. Yager *Proc. 18th Int. Conf. Auditory Disp.*; ICAD, 2012).

Now, Schedel helps scientists to use sonification to expand their understanding of their data and to go beyond visual interpretations of their analyses.

Selling science

Although sound can deepen data analysis, physicist David Mahon at the University of Glasgow, UK, sees it as a way to connect with a non-scientist audience.

Mahon studies muons, subatomic particles produced when cosmic rays strike Earth's atmosphere. Muons are harmless radiation that are used by researchers to image inside inaccessible cavities, such as nuclear waste containers or volcanoes. But Mahon, a self-described 'muonophile' admits that, outside his field, muons are a hard sell for the public.

"Music gave us the opportunity to connect our science in a more personal way."

And muon detectors are unglamorous: "What they do is amazing but how they do it is boring," Mahon says.

So, in a quest to jazz up muons, Mahon reached out to musician, artist and inventor Lomond Campbell. Campbell crafted an instrument called a Muonophone, which transformed detected muons into a constantly shifting electronic soundscape.

Chemist Colin Campbell plays the bagpipes.

ELEANOR CAMPBELL

At the Edinburgh Fringe Festival performing-arts event in 2025, Campbell performed a keyboard duet alongside the cosmic forces in a show called MŮO. Sitting in the dark at MŮO, listening to the sound of muons as they hit Earth's surface was a "surreal experience", Mahon says.

At the event, Mahon's graduate students spoke about muons with concert goers. The responses were overwhelmingly positive, Mahon says, and he thinks that the event raised awareness about how radiation can be used for good and could inspire students to pursue physics.

Harnessing emotions

Similarly, Hiroto Nagai, a geoscientist at Rissho University in Kumagaya, Japan, relies on music to create a visceral connection between listeners and climate concepts.

Nagai, an amateur composer and musician who plays piano, saxophone and a string instrument called a mandocello wanted to promote a broader understanding of Earth's climate system. So, he composed a haunting 6-minute piece for a string quartet, using satellite and meteorological data from the planet's polar regions.

He first wrote a computer program to extract the observational data and turn it into musical scale and pitch, which took about three months. Then, his job as musical storyteller began as he arranged the playable sounds into a narrative that vacillated between harshness, gentleness and warmth.

In March 2023, a string quartet played his composition 'Polar Energy Budget' live at Tokyo's Waseda University. Nagai posted an annotated performance video online (see go.nature.com/3yrzvqx) and wrote an article about the project (H. Nagai *iScience* **27**, 109622; 2024). The video received more than 14,000 views, which Nagai credits to music's universal ability to stir emotions.

Music forcefully grabs attention, whereas visual data requires people to look at it, inspect and parse it, Nagai says. And a musical hook opens a door to communication. "It creates the first emotional connection that can lead to deeper scientific dialogue," Nagai says.

In a similar vein, music can spark an intuitive understanding of the vast scales and slow-moving trends implicit in Earth's natural phenomena, says Molly James, an oceanographer at the University of Connecticut in Groton.

James teamed up with Maxwell Lu, a composer at Columbia University in New York, and South Korean pianist Sophy Chung to create music using data from the 2011 Tōhoku earthquake and tsunami in Japan and, in stark contrast, from data recordings of the slow, almost imperceptible creep of the ocean's rise along the US Long Island Sound shoreline. The latter resulted in a nearly 9-minute piece

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Lomond Campbell makes soundscapes from detected subatomic particles called muons.

called 'sea level rise', which starts off slow, then increases in intensity as the oceans' rise accelerates. "Now sea-level rise isn't this abstract, conceptual thing," James says.

Playing your science

After the Data Jam Workshop in Edinburgh, Hong and Levinsky decided to hold an evening showcase for attendees to perform and explain their data-driven creations.

Presenting data as music can help audiences to understand the nuances of specialized research, Levinsky says. Whereas it can be hard to spot fluctuations on a graph, "nearly everybody can hear a change in pitch", Levinsky says. "That can make the data easier to understand."

The showcase also helped colleagues to build an appreciation of each other's work within the chemistry department, Levinsky says. To create his composition 'Bucky V2' (named after buckyball carbon molecules), Levinsky teamed up with his colleague at Edinburgh, computational biochemist Chenfeng Zhang. Although the two's daily work never overlapped, they shared a love for hip-hop. "Music gave us the opportunity to connect our science in a more personal way," Levinsky says.

Levinsky and Zhang crafted the main melody of their piece directly from the infrared spectrum of the buckyball molecule, then they added drums and bass before arranging everything into a coherent piece. The two put the music to a video collage of Levinsky's trips for experiments at the Diamond Light Source near Oxford, UK, including brief snapshots of everyday life as a scientist, such as an empty vending machine in the early hours.

"It can be difficult to explain what I do on a day-to-day basis to people outside of science in a way that I feel understood or is accurate," Levinsky says, but this project did that.

Crafting music from research findings embodies the essence of curiosity, Colin Campbell says. It enables researchers to explore concepts and interpretations in a non-judgemental way, providing a welcome break from the constant pressure to publish and secure funding. Campbell thinks that the process can also convey an important message to students considering a career in science: "One of the most underappreciated elements of being a professional scientist is that you have to be really creative."

Campbell played 'Nanog' on the bagpipes at the Data Jam showcase alongside eight other performances by University of Edinburgh researchers, including environmental scientist Niamh Gurrin's upbeat electronic representation of soil structure and an atomic dance mix created by chemistry PhD student David Coventry and senior chemist Claire Hobday. Coventry crafted a funky track from data from crystals that he grew, and Hobday used simulation data to generate a movie of the crystal atoms twirling. "It made you want to dance," Hong says. The musification workshop and performances introduced an element of play into the scientific endeavour, she says. "It was like a game. It brought up so much joy."

Jane Palmer is a freelance journalist in Boulder, Colorado.