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Weizmann Institute Scientists Produce

The First Smell Map

Is the smell of almonds closer to that of roses or bananas? Weizmann Institute scientists have now answered that question (roses) by showing for the first time that smells can be mapped and the relative distance between various odors determined. Their findings, which appeared recently in *Nature Methods*, may help scientists to unravel the basic laws underlying our sense of smell, as well as potentially enabling odors to be digitized and transferred via computer in the future.

We know the musical note *do* is farther from *la* than from *re* on a scale – not only because our ears tell us the distance is greater, but because their frequencies are farther apart. No such physical relationship had been discovered for smells, in part because odor molecules are much more difficult to pin down than sound frequencies. To create their map, the scientists began with 250 odorants and generated, for each, a list of around 1,600 chemical characteristics. From this dataset, the researchers, led by Rafi Haddad, a graduate student with Prof. Noam Sobel in the Neurobiology Department, and Prof. David Harel of the Computer Science and Applied Mathematics Department, together with their colleague Rehan Khan, created a multi-dimensional map of smells that revealed the distance between one odor molecule and another.

Eventually, they pared the list of traits needed to situate an odor on the map down to around 40. They then checked to see whether the brain recognizes this map, similar to the way it recognizes musical scales. They reexamined numerous previously published studies that measured the neural response patterns to smells in a variety of lab animals – from fruit flies to rats – and found that across all the species, the closer any two smells were on the map, the more similar the neural patterns. The scientists also tested 70 new odors by predicting the neural patterns they would arouse and running comparisons with the unpublished results of olfaction experiments done at the University of Tokyo. They found that their predictions closely matched the experimental results.

The closer any two smells were on the map, the more similar the neural patterns

These findings lend support to the scientist's theory that, contrary to the commonly held view that smell is a subjective experience, there are universal laws governing the organization of smells, and these laws determine how our brains perceive them. ❙

Prof. Noam Sobel's research is supported by the Nella and Leon Benoziyo Center for Neurosciences; the J&R Foundation; and the Eisenberg Keefer Fund for New Scientists.

Prof. David Harel's research is supported by the Arthur and Rochelle Belfer Institute of Mathematics and Computer Science; and the Henri Gutwirth Fund for Research. Prof. Harel is the incumbent of the William Sussman Professorial Chair.

Weizmann Institute Scientists Build

A Better DNA Molecule

Building faultless objects from faulty components may seem like alchemy. Yet scientists from the Weizmann Institute's Computer Science and Applied Mathematics, and Biological Chemistry Departments have achieved just that, using a mathematical concept called recursion. "We all use recursion, intuitively, to compose and comprehend sentences like 'the dog that chases the cat that bit the mouse that ate the cheese that the man dropped is black,'" says Prof. Ehud Shapiro.

Recursion allows long DNA molecules to be composed hierarchically from smaller building blocks. But synthetic DNA building blocks have random errors within their sequence, as do the

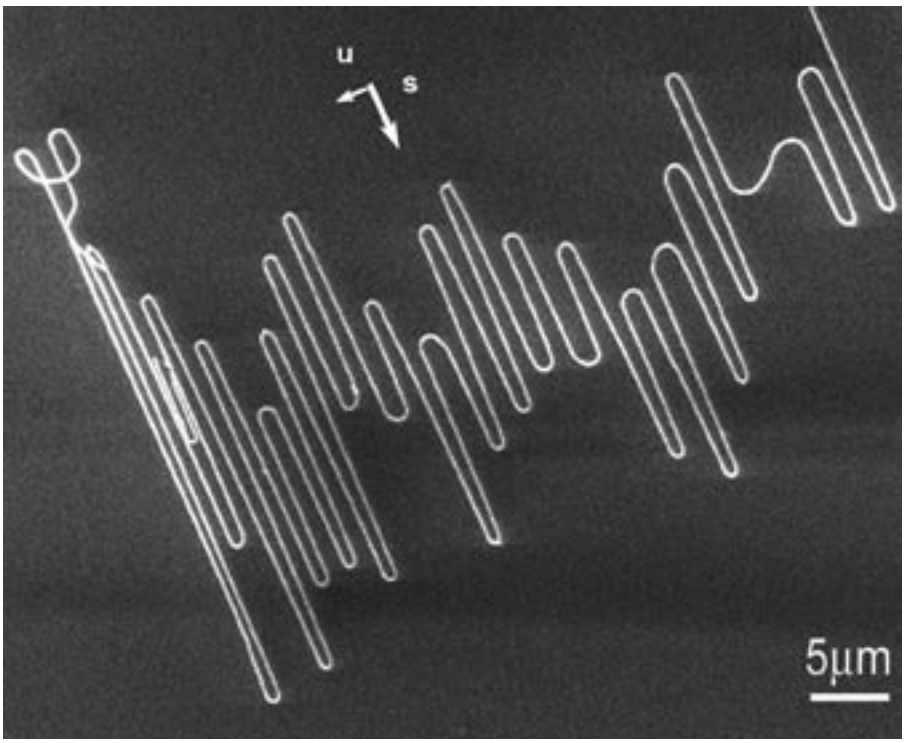
resulting molecules. Correcting these errors is necessary for the molecules to be useful. Even though the synthetic molecules are error prone, some of them are likely to have long stretches that do not contain any faults. These stretches of faultless DNA can be identified, extracted, and reused in another round of recursive construction. Starting from longer and more accurate building blocks in this round increases the chances of producing a flawless long DNA molecule. The team, led by doctoral students Gregory Linshiz and Tuval Ben-Yehezkel under the supervision of Shapiro, found in their experiments that two rounds of recursive construction were enough to produce a flawless target DNA molecule. If need be, however, the error correction procedure could be repeated until the desired molecule is formed.

The team's research, recently published in the journal *Molecular Systems Biology*, provides a novel way to construct faultless DNA molecules with greater speed, precision, and ease of combining synthetic and natural DNA fragments than existing methods. "Synthetic DNA molecules are widely needed in biological and biomedical research, and we hope that their efficient and accurate construction using this recursive process will help to speed up progress in these fields," says Shapiro. ❙

Prof. Ehud Shapiro's research is supported by the Clore Center for Biological Physics; the Arie and Ida Crown Memorial Charitable Fund; the Cymerman - Jakubskind Prize; the Fusfeld Research Fund; the Phyllis and Joseph Gurwin Fund for Scientific Advancement; the Henry Gutwirth Fund for Research; Ms. Sally Leafman Appelbaum, Scottsdale, AZ; the Carolito Stiftung, Switzerland; the Louis Chor Memorial Trust Fund; and the estate of Fannie Sherr, New York, NY. Prof. Shapiro is the incumbent of the Harry Weinrebe Chair of Computer Science and Biology.

Weizmann Institute Scientists Create

New Nanotube Structures



A nanotube serpentine observed by scanning electron microscopy. Arrows marked u *and* s *indicate the directions of gas flow and atomic steps, respectively*

Thanks to the rising trend toward miniaturization, carbon nanotubes – which are about 100,000 times thinner than a human hair and possess several unique and very useful properties – have become the choice candidates for use as building blocks in nanosized electronic and mechanical devices. But it is precisely their infinitesimal dimensions, as well as their tendency to clump together, that make it difficult for scientists to manipulate nanotubes.

Dr. Ernesto Joselevich, together with Ph.D. student Ariel Ismach and former M.Sc. student Noam Geblinger of the Weizmann Institute's Materials and Interfaces Department, are developing techniques to coax carbon nanotubes to self-assemble into ordered structures – essentially making the nanotubes do the hard work for them.

Ironically, the universal principle of "order through chaos," has allowed the team's most recent research to give rise to nanotubes that are strikingly more ordered and complex than any ever observed before. These intriguing new nanotube structures, which the scientists have dubbed "serpentines" due to their self-assembly into snake-like or looped configurations, have recently been reported in the cover article of the journal *Nature Nanotechnology*.

"It may seem paradoxical – trying to create order through chaos – but in fact, this a common phenomenon on the macroscale. Systems affected by forces that fluctuate from one extreme to another tend to self-organize into much more complexly ordered structures than those in which the external forces are 'calm.' We applied this principle at the nanoscale to see if it would have the same effect, and indeed, it did," says Joselevich.

Serpentines are a common geometry in many functional macroscale systems: antennas, radiators and cooling elements. Analogously, nanotube serpentines could find a wide range of nano-device applications, such as cooling elements for electronic circuits and opto-electronic devices, as well as in power-generating, single-molecule dynamos. "But the feature I find most intriguing about these serpentines," says Joselevich, "is their beauty." ❙

Dr. Ernesto Joselevich's research is supported by the Helen and Martin Kimmel Center for Nanoscale Science; and the Gerhardt Schmidt Minerva Center on Supramolecular Architectures. Dr. Joselevich is the incumbent of the Dr. Victor L. Ehrlich Career Development Chair.

An animated movie explaining nanotube serpentine formation can be seen at www.youtube.com/watch?v=8znin1nSo_I