
From left: presidential contenders Emmanuel Macron, Jean-Luc Mélenchon and François Fillon.

JULIEN DE ROSA/IP3/GETTY; CHRISTOPHE MORIN/IP3/GETTY; PASCAL GUYOT/AFP/GETTY

▶ Daniel Stockemer, a political scientist at the University of Ottawa. But the party founded by her father, Jean-Marie Le Pen, in the early 1970s remains extremist and illiberal, says Stockemer: "The core programme is the same; all that has changed is its communication strategy." For all the political jitters, a Le Pen victory is "impossible", Stockemer thinks. Le Pen's core electorate still consists largely of people with extremist right-wing views, he says, which puts a ceiling on the number of voters she can attract in a head-to-head run-off. "The Front National is not the catch-all party that is needed to win a presidential election," he says.

Villani, who directs the Henri Poincaré Institute in Paris, also highlights the threat that Le Pen poses to the European Union. She has promised to renegotiate France's terms of membership with the EU, and to hold a referendum on the country's place in the bloc and on leaving the euro currency. Last month, in response, Villani joined the campaign of Macron — the most pro-European candidate. Macron is also widely considered best placed to roundly defeat Le Pen in a head-to-head.

Le Pen has a vision of a society closed in upon itself, while researchers tend to have an international outlook, says Édouard Brézin, an emeritus theoretical physicist at the École Normale Supérieure in Paris and former president of the French National Centre for Scientific Research (CNRS). "Any French retreat from Europe would be far more significant than Brexit," adds Brézin.

As well as holding numerous interviews, *Nature* e-mailed more than 3,500 scientists in France, requesting them to take part in an anonymous online survey. The results, from 173 researchers who had replied by 17 April, are far from a representative poll of scientists' voting intentions, but reflect a trend among some French researchers to veer to the left of the political spectrum. They show Macron as the clear frontrunner, well ahead of Mélenchon and Hamon, and even further ahead of Fillon, with almost no support for Le Pen.

Asked expressly to comment on research policy priorities for France's next president, survey respondents said they would like to see more funding for basic and long-term research; more science on topics directly relevant to citizens, such as agriculture and the environment; and a simplification of complex grant-application procedures. In fact, continuity is the most likely outcome for France's research policies after the elections, says Rémi Barré, a science-policy expert and an emeritus researcher at the National Conservatory of Arts and Crafts in Paris. Reforms instigated under the presidencies of Jacques Chirac and Nicolas Sarkozy, and refined under François Hollande — such as efforts to give universities more independence from the state — are likely to carry on. Economic constraints mean that the next president and government will probably have little opportunity to raise research budgets significantly, he says. ■

NANOTECHNOLOGY

Drivers gear up for world's first nanocar race

Molecular wagons will navigate tiny course along golden track.

BY DAVIDE CASTELVECCHI

Six teams from three continents are preparing for a unique race on a polished gold track in the south of France this month. But this is no luxurious supercar event: competitors will be racing single molecules. In 36 hours, they aim to move them a distance of 100 nanometres — about one-thousandth the width of a human hair — on a laboratory track held in a vacuum and chilled to a few degrees above absolute zero.

The contest is being billed as the world's first nanocar race, and the aim is to get people excited about nanotechnology and molecular machines, says co-organizer Christian Joachim, a chemist who works at the Centre for Materials Elaboration and Structural Studies in Toulouse, where the event will take place. He and Gwénaël Rapenne, a chemist at the University of Toulouse-Paul Sabatier, developed the contest after Joachim realized — following an interview with a journalist — that nanocars attracted much more public attention than did his research on fundamental aspects of nanotechnology.

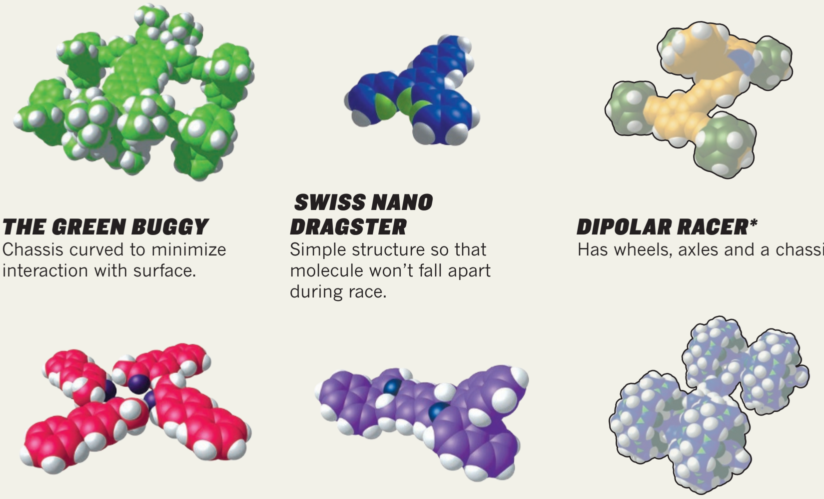
The race may also provide scientific insights for the contestants, who want to learn more about how their individual molecules interact with surfaces. That may help in the design of catalysts and, in the longer term, further the aim of creating molecular-scale technologies for transporting cargo or information, participants say. "It's a gigantic experiment, performed by many people at the same time," Joachim says. (*Nature Nanotechnology*, which is independent of *Nature*'s news team, is a sponsor of the race.)

ELECTRON FUEL

The term nanocar is actually a misnomer, because the molecules involved in this race have no motors. (Future races may incorporate them, Joachim says.) And it is not clear whether the molecules will even roll along like wagons: a few designs might, but many lack axles and wheels. Drivers will use electrons from the tip of a scanning

MOLECULAR RACE

Six 'nanocars' will vie for supremacy in a race along a gold track.



*Prototype model: final design not revealed

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tunnelling microscope (STM) to help jolt their molecules along, typically by just 0.3 nanometres each time — making 100 nanometres "a pretty long distance", notes physicist Leonhard Grill of the University of Graz, Austria, who co-leads a US–Austrian team in the race.

Contestants are not allowed to directly push on their molecules with the STM tip. Some teams have designed their molecules so that the incoming electrons raise their energy states, causing vibrations or changes to molecular structures that jolt the racers along. Others expect electrostatic repulsion from the electrons to be the main driving force. Waka Nakanishi, an organic chemist at the National Institute for Materials Science in Tsukuba, Japan, has designed a nanocar with two sets of 'flaps' that are intended to flutter like butterfly wings when the molecule is energized by the STM tip (see 'Molecular race'). Part of the reason for entering the race, she says, was to gain access to the Toulouse lab's state-of-the-art STM to better understand the molecule's behaviour.

Eric Masson, a chemist at Ohio University in Athens, hopes to find out whether the 'wheels' (pumpkin-shaped groups of atoms) of his team's car will roll on the surface or simply slide. "We want to better understand the nature of the interaction between the molecule and the surface," says Masson.

Simply watching the race progress is half the battle. After each attempted jolt, teams will take three minutes to scan their race track with the STM, and after each hour they will produce a short animation that will immediately be posted online. That way, says Joachim, everyone will be able to see the race streamed almost live.

NANOSCALE RACES

Chemists have previously created tiny nanocars with wheels and axles — as well as molecular rotors and switches. The 2016 Nobel Prize in Chemistry, awarded to creators of nanomachines, has renewed interest in the field. However, the Nobel prizewinners worked mainly with large numbers of molecules in solution, Joachim says, whereas the researchers in this race are focusing on the interactions between single molecules and solid surfaces.

But cars on the nanoscale behave nothing like their real-life counterparts, making it hard to find uses for the machines. At these scales, electrostatic forces dominate and random thermal vibrations constantly shake molecules around. Consequently, nanomachines may end up behaving in unexpected or unpredictable ways, Grill says.

The Toulouse laboratory has an unusual STM with four scanning tips — most have only one — that will allow four teams to race at the same time, each on a different section of the gold surface. Six teams will compete this week to qualify for one of the four spots; the final race will begin on 28 April at 11 a.m. local time. The competitors will face many obstacles during the contest. Individual molecules in the race will often be lost or get stuck, and the trickiest part may be to negotiate the two turns in the track, Joachim says. He thinks the racers may require multiple restarts to cover the distance. ■

MECHANICAL ENGINEERING

Unravelling a knotty problem

Huge forces lead to runaway failure of shoelace knots.

BY ERIN ROSS

Oliver O'Reilly was teaching his daughter to tie her shoes when he realized something: he had no idea why shoelaces suddenly come undone. No one else seemed to know either.

So O'Reilly, a mechanical engineer at the University of California, Berkeley, roped in two of his colleagues to help work it out. In a paper published on 12 April, they show that a combination of forces act on shoelace knots to cause a sudden, runaway failure (C. A. Daily-Diamond *et al. Proc. R. Soc. A* http://doi.org/b5p5; 2017).

The scientists expected that the knots would come undone slowly. But slow-motion video footage — focused on the shoelaces of a runner on a treadmill — showed that the knots failed rapidly, within one or two strides. To find out why, O'Reilly and his colleagues measured the forces acting on a knot. They found that when walking, the combined impact and acceleration on a shoelace totals a whopping 7 *g* — about the same force that Apollo spacecraft experienced on re-entry to Earth's atmosphere.

Further experiments demonstrated that simply stomping up and down wasn't enough to cause a knot to fail; neither was swinging it back and forth. It took the interlaced effects of the two forces to undo the knot: the repeated impacts loosened it while the changes of direction pulled on the laces.

This interest in why knots come untied is more than purely academic, says Khalid Jawed, a mechanical engineer at Carnegie Mellon University in Pittsburgh, Pennsylvania.

Shoelace knots are the simplest type of knot, called the trefoil, he says. And most commonly used knots are just a combination of trefoils. "If we understand how simple knots work and fail, we can understand more complex knots," he says.

This could help to create better surgeon's knots and unravel why deep-sea optic cables become tangled and break. It could also improve how computer animators mimic the movement of hair, because it moves and twists in a similar way to strings and knots.

O'Reilly encourages people to experiment the next time they walk or run. They could tie their shoes with different knots and see how their laces fare. But tread carefully: you don't want to trip. ■