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Growing the Adolescent Mind

Recycling Space Junk

Redefining Alzheimer's

A Cellular Revolution

Long-overlooked molecular blobs are transforming our understanding of how life works

FEBRUARY 2025
SCIENTIFICAMERICAN.COM

before I read the book, that the children came well after she'd established herself as a scientist.

This is a very female story. She had two children; she had a miscarriage; she had trouble nursing. Some of the women who came to her lab stopped working when they got married and had children. It's been more than 100 years, and that's still true for many women in science. I really wanted to meet those issues directly in the book because I think it's so important for young women to read about other female scientists and how they managed.

Did Curie actively set out to recruit more women into science?

I don't think she was specifically looking to hire women, but what was different about her was that she had nothing *against* hiring them. So that was big, and then again she was so prominent that she attracted them and inspired them. There are a couple of women in the story who were much younger and grew up hearing about her, which made them think, "Oh, I could be a scientist, too." And the amazing thing to me is how she still has that effect. She's been dead for almost 100 years, but she is still an inspiration—and not just to women who go into science but to women in a variety of fields.

What do you think most people get wrong about Marie Curie?

You'll often hear that she didn't really do anything: it was all Pierre, and she was just his assistant. Pierre himself was on record debunking that, but nobody listened.

Another criticism was, "She used her hands but not her head. She was very involved in doing all of this very difficult chemical extraction, which required repetition of many steps, and that was what she was good at." That is also a very familiar trope about women in science: that women do this grunt work, the boring things, and the men just have aha! moments 24 hours a day.

That kind of attitude is just one aspect of the type of resistance Curie faced. What was the climate like at the time for women in science?

She was operating in this environment of huge sexism. She was barred from the French Academy of Sciences. Even though she had a lot of support, they did not vote her in, and to be published in their weekly proceedings, to present your work, you had to be a member. So she was constantly having to ask friends to present the work of the people in her lab, which was an enormous embarrassment. She was the premier authority on her subject, and she didn't have the standing in the professional community that she deserved. And then later her daughter tried several times to get voted into the academy. She was also a Nobel Prize winner, and she couldn't get in, either. So, yes, there was a lot of sexism, a lot of barricades, but she broke through most of them.

Beyond promoting individual women in science, how do you think Curie changed science for women after her?

We're talking about the early 1900s, so physics altogether was at an inflection point, and she was, for three decades, the only woman in the room at these important Solvay Conference meetings [a groundbreaking series of physics congresses that began in 1911]. So she knew all the top physicists: Ernest Rutherford, Albert Einstein, Enrico Fermi, Niels Bohr, everybody. She knew them personally, and I think she normalized some of that for them—that "oh, yeah, women do this, too," which might not have occurred to them. So I think, by her presence, she had an effect on her peers.

You are* Scientific American*'s poetry column editor. Is there any connection between Curie and poetry?

Well, being Polish and being in a family that was very nationalistic, very proud of its Polish heritage, she grew up on three very famous Polish poets: Adam Mickiewicz, Zygmunt Krasiński and Juliusz Słowacki. Her family also had a tradition of writing verses on this or that occasion, and she wrote a couple of poems. She wrote about her life as a student when she was first in Paris. I don't think she ever wrote any poems about her work. And there have been a lot of poems written about her. Even Adrienne Rich wrote a poem about Madame Curie. ●

The Roundest Object in the Universe

Finding a perfect sphere is actually pretty difficult

BY PHIL PLAIT

EVERY NOW AND AGAIN I'll get a weird thought in my head that sits there demanding an answer. Sometimes it's trivial, and sometimes it sounds silly but then leads to some fun insights. This time my brain decided to fixate on a simple question: What's the roundest object in the universe?

By that I mean, what is the most spherical object we've ever found—not necessarily the smoothest but the most symmetrical, where every point on its surface is the same distance from its center? (That's the definition of a sphere, after all.)

Lots of big things are round, and that's no coincidence. Gravity is to blame. As a cosmic object grows, usually by accumulating gas or via collisions with other bodies, its mass increases—and therefore its gravitational field increases, too. At some point the gravity gets so strong that anything sticking up too high will collapse, a process that eventually drives the object to become spherical. This mechanism is part of our lives on Earth: a mountain that gets too tall will crumble, and you can pile sand only so high at the beach before it will topple. Every time an astronomical object undergoes this kind of change, it becomes more smooth, more spherical.

This property emerges for objects once they grow to roughly 400 kilometers across, depending on what they're made of. So almost any discrete body with this diameter or larger will tend to be nearly spherical: big asteroids, moons, planets and even stars.

So which of these are the most geometrically perfect orbs? I poked around quite a bit, thinking of every kind of astronomical object I could, and in the end the answer I got was a surprise: the sun—yes, our nearest star!

Stars in general are quite round, but even the roundest ones deviate from being an ideal sphere. The main source of this departure is rotation because it creates centrifugal force.

Despite what you might have heard, centrifugal force is indeed real within a rotating reference frame—that is, if you're on a curving trajectory, this force makes it feel like something is pushing you outward. If you're in a car making a left turn, for example, you feel like you're being thrown to the right, to the outside of the turn.

For spinning spheres, centrifugal force is maximized at the equator, where the rotational speed is highest. The amount of the force depends on the size of the object and how fast it's spinning—bigger ones experience more force, and faster spins increase the force as well.

The sun is big, no doubt: more than 100 Earths could fit across its 1.4-million-kilometer-wide face. But at the same time, our star spins slowly, taking roughly a month to rotate once. This sedate spin is what may make it the winner of the roundness contest.

The sun's surface gravity is quite strong, about 28 times that of Earth—if you stood on its surface (and avoided being instantly vaporized), you'd weigh 28 times more than you do on Earth. But the centrifugal force at the solar equator is much weaker; the outward force you'd feel from our star's spin is only 0.0015 percent the force of gravity pulling you down right now. No wonder the sun is so round.

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Precisely measuring how round the sun is, though, turns out to be hard. It doesn't have a surface quite like Earth does; it's gaseous, so the material inside it gets less and less dense the farther away it is from the center. Near the "surface," however, the density drops so rapidly that from Earth the sun's edge appears sharp. Measuring the sun's size from the ground is hard because Earth's air is turbulent, smearing out the view of that edge. So to get a really good look at the sun's sphericity, astronomers turned to nasa's Solar Dynamics Observatory, a space-based astronomical sun telescope.

By taking very careful measurements, they found that the sun's oblateness—how much it is flattened at the pole versus the equator—is incredibly small, with a ratio of just 0.0008 percent. That means the sun is 99.9992 percent spherical. These results were published in the journal *Science Express*.

That's dang round. Weirdly, the scientists also found that this ratio doesn't seem to change with the sun's magnetic cycle. Right now we're at the peak of the strength of the sun's magnetism, which waxes and wanes on an 11-year cycle. But this powerful force doesn't seem to bother the sun's unbearable roundness of being at all.

I'll note that another solar system body is nearly this round: Venus—and for the same reason. Venus is an extremely slow spinner; it takes about 243 days to rotate once. That means the centrifugal force at its equator is very small indeed, and in fact, observations indicate the polar and equatorial widths of the planet are exactly the same to within measurement error.

This attribute makes it arguably rounder than the sun in principle, although in reality, it has surface-elevation variations of several kilometers, and so to scale, it's not as round as our star. (Earth's oblateness is about 0.3 percent because our planet rotates much faster than these other bodies.) That's true for planets in general, so Venus is neither sphere nor there.

Other stars, though, can be shockingly aspherical. One reason is that some rotate so rapidly that the centrifugal force at their equator is enormous; the bright star Altair is spinning so quickly that material at its equator is screaming along at nearly a million kilometers per hour. As a result, its equatorial diameter is 20 percent

Venus is seen (*at top*) transiting the sun. Both objects are almost perfectly round—more spherical, in fact, than most other celestial bodies precisely measured by astronomers.

LinP74/Getty Images

wider than its diameter through the poles.

Other objects may be even rounder than our sun, but they are so far removed from our probing instruments that we can't precisely discern them. Some, however, we can somewhat reliably scrutinize from first principles—such as neutron stars, which, as a class, are true heavyweight contenders for Most Spherical Object. Each of these überdense orbs is the remnant of a star more massive than the sun that underwent a supernova; the core of the star collapsed to essentially become a ball of neutrons a mere two dozen kilometers across. Neutron stars are so dense that their surface gravity can be billions of times Earth's.

Various forces can cause some neutron stars to spin extremely rapidly, however; one star called PSR J1748-2446ad spins a whopping 716 times per second! That's higher than the rate of the blades in a kitchen blender. The centrifugal force at the star's equator, despite the orb's cosmically Lilliputian size and Brobdingnagian gravity, is almost enough to rip it apart.

Over time, though, a neutron star's spin slows, and one that formed early in the universe could now be nearly static. In that case, the intense gravity (I'd weigh upward of a billion tons standing on one) would be enough to crush the neutron star to a very nearly perfect sphere, perhaps with the difference in flattening between its equator and poles measured in widths of atoms. Will astronomers ever find one this spherical? Maybe, once they get around to it.

This question is more than just playful, though. It's difficult to understand the internal structures of many cosmic objects because we can't visit them, and their pressures and temperatures can be far too great even to replicate in a laboratory. By measuring the exact shapes of things like the sun and the planets, we learn more about what happens under their surface and discover what makes them tick.

Astronomers love to figure this kind of thing out, even when it means asking what sound like silly questions. That part is fun, sure, but finding the answer is when we really have a ball. ⬣

How Expertise Improves Concentration

Practice in a task strengthens our ability to think deeply, a skill the brain may generalize

BY HANNA POIKONEN

THINK OF THE LAST TIME you concentrated deeply to solve a challenging problem. To crack a math puzzle or determine a chess move, for example, you might have had to screen multiple strategies and approaches. But little by little, the answer to the conundrum came into focus. Numbers and symbols may have fallen into place. It might have even felt, at some point, like your problem effortlessly resolved itself on the blackboard of your mind.

In recent research, my colleagues and I investigated the neural mechanisms underlying these experiences. Specifically, we wanted to understand what happens in the brain while a person engages in abstract and demanding thought—so we designed a study involving math expertise.

Hanna Poikonen is a senior researcher and lecturer at ETH Zürich. She studies the brain functions underlying expertise, including in mathematicians, dancers, musicians and political enthusiasts.

Mathematical thinking relies on an ancient brain network located in the parietal regions, at the top and center of the brain's outer folded cortex. This network helps us process space, time and numbers. Previous studies on neurocognition in mathematics focused on what happens in the brain while people consider problems that take a few seconds to solve. These studies have helped illuminate brain activity that supports focused attention and a special form of recall called working memory, which the brain uses to keep numbers and other details top of mind in the short term.

In our work, we used longer, more complex math

Illustration by Thomas Fuchs