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MAY 2024
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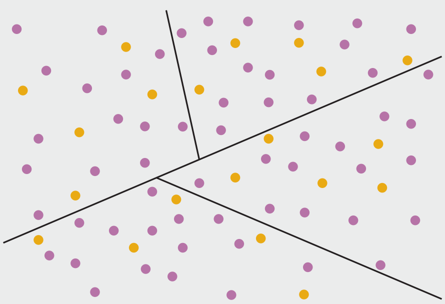
Of course, those districts look highly artificial. A seemingly obvious way to curtail gerrymandering would be to place restrictions on the shapes of the districts and disallow the tentacled monstrosities that we often see on American electoral maps. Indeed, many states impose such rules. Although it might seem like mandating "normal" district shapes would go a long way toward ameliorating the problem, clever researchers have applied a certain geometric theorem to show how that's a bunch of baloney.

Let's revisit our example: a total of 80 voters consisting of 60 Purple Party supporters and 20 Yellow Party supporters. The ham sandwich theorem tells us that no matter how they're distributed, we can draw a straight line with exactly half of the Purple voters and half of the Yellow voters on either side (30 Purple and 10 Yellow on both sides). Now treat the two areas you've created as new ham sandwiches, splitting each in half with its own straight line so that every resulting region contains 15 Purples and five Yellows. Purple now has the same gerrymandered advantage as before (it wins every district), but the resulting regions are all simple shapes with straight-line boundaries!



Repeated ham-sandwich subdivision will always produce relatively simple districts (in math-speak, they're convex polygons except where they potentially share a boundary with an existing state border). This means that basic regulations on the shapes of congressional districts probably can't preclude the worst instances of gerrymandering. Although math and politics may seem like distant fields, an idle geometric diversion has taught us that the most natural-sounding solution to gerrymandering doesn't cut the mustard. ⬣

When We Find Earth 2.0, What's Next?

It might not be long before astronomers announce an Earth analogue BY Phil Plait

WHEN I WRITE or give public talks about exoplanets—alien worlds orbiting other stars—the most common question I'm asked is, "When will we find another Earth?"

It's a good question. As we're learning, space is filled with a great many wildly differing worlds, and it's natural to wonder whether there's an Earth 2.0 out there or whether they're all truly, well, alien.

Our galaxy, the Milky Way, harbors hundreds of billions of stars. A recent census of local stars shows that planets occur at least as often as stars, so there could be trillions of planets in our galaxy alone. Of course, realistically, that doesn't mean every star has a planet; rather some don't have any, and others have teeming solar systems.

Exoplanets come in a dizzying variety of types, some incredibly bizarre: planets as big as Jupiter but skimming so close to their host stars' surfaces that the scorching heat strips away their atmosphere, turning them into mega comets; worlds bigger than Earth but smaller than Neptune, which are the most common kind of exoplanet seen despite our solar system's lack of one; and planets where it might rain molten iron. Oddballs abound.

And, yes, the list includes many Earth-size worlds. Of the 5,500 or so exoplanets found to date, about 100 are close in size to our home planet. But there's more to Earth than just its size.

If you're looking for an exact replica—say, with Earth's size, mass and composition, as well as breathable air and drinkable water—those odds look pretty long. Planetary formation involves a lot of random variables that affect how a planet forms and evolves over time. Even small changes can lead to dramatically different planetary evolution, and many of these variables interact. For example, a planet a little bit warmer than Earth—perhaps orbiting a hotter star or closer to a cooler star—could wind up with a runaway greenhouse effect that boils its oceans and eventually heats its desiccated surface to the melting point of lead. There but for the grace of Venus go we.

As we're experiencing now, even a relatively small change in atmospheric carbon dioxide can have profound effects on the global environment. This factor alone probably won't make Earth uninhabitable, but the changes are happening rapidly enough that they're making things decidedly uncomfortable.

On top of that, Earth hasn't always been Earth-like as we understand it. For two billion years our world lacked what we would consider a breathable atmosphere, and it was only through a catastrophic environmental change that free oxygen became available. It's also possible that our planet went through at least one period of total glaciation, the hypothetical "snowball Earth" era. Although this last idea is controversial, it's clear that for long periods Earth was not the clement home we now know.

Moreover, there's growing consensus in the scientific community around the idea that Mars was once more habitable than its current thin atmosphere and dry surface would imply. Several billion years ago it might have been more like Earth is now than Earth was then. Perhaps even Venus—now a decently convincing version of hell—could have once been habitable.

Even the very notion of habitability is fuzzier than you might think. There are icy moons in the outer solar system that have oceans of water under their frozen surfaces, as well as other conditions poten-

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An illustration of an Earth-size exoplanet

Miguel Perfectti/Getty Images

tially conducive for life. Eternal darkness in temperatures just above freezing may not sound like Eden, but it could be paradise for life that evolved there.

All this is to say we don't think we've found a planet orbiting another star that's just like Earth. For one thing, we don't know enough about the atmospheres and chemical compositions of these worlds to say whether they're Earth-like. Of the 100 Earth-size exoplanets mentioned earlier, only three also have roughly Earth's mass and receive about the same amount of light and heat from their host star. Three. That's a tiny fraction, but to be fair, our current discovery methods are better at finding big, hot planets. Small, mild ones like our own are far tougher to spot.

But methods improve all the time, and we may not have to wait too much longer for astronomers to announce they've found an Earth analogue among the stars. When we do, what then?

It's not like we can go there. There's no USS *Enterprise* we can use to warp over to the nearest Earth 2.0, and without faster-than-light travel, it would be a long trip. Even the fastest spaceship ever launched would take the better part of a millennium to get to the nearest star system, Proxima Centauri (which does actually host an Earth-size planet that might—might—be within our range of acceptability). Better pack a lunch.

So many sci-fi movies tell us we need to evacuate Earth that it's a trope. This idea is far more fi than sci, though; humanity increases its number by more than 70 million people every year. You'd need to launch 2,000 SpaceX Starships every day just to keep up with that increase, even ignoring the less than helpful travel times. Easing population pressure via interstellar immigration is a nonstarter.

Establishing a settlement is a tall order, too. We don't even really know how to do this in low-Earth orbit, on the moon or on Mars. We're a long, long way from being able to set up shop on an alien Earth even if we could easily get to one.

When I'm asked about Earth 2.0, the implicit part of the question is whether we can travel to it and live there. Simply put, we can't. So why look if we can't go?

Because—to paraphrase a possibly apocryphal answer to a similar question—it's probably there. We look because we want to know.

Searching for an Earth clone isn't the point of exoplanetary science—except it really kind of is. Scientifically speaking, we look for other planets because we want to understand how they form, how conditions change their physical properties, and how they differ from or mirror the planets in our own solar system.

But emotionally, we yearn to see another pale blue dot somewhere out in the depths of space, to know that somewhere, sometime, conditions were just so to replicate—or at least resemble—those with which we are so familiar. Certainly, just knowing it's out there would profoundly change the way we see the universe and our place in it. Such a discovery would also help us understand Earth better.

It may also help us answer the most fundamental question humans have ever had: How did we get here? For millennia this question has inspired speculation, myth, religion and philosophy. With a distant blue-white world hovering in the eyepiece, it becomes science. Knowable. And then we can, perhaps, indulge ourselves further. If we find another habitable world, we can dare to crack open the door for the next Big Question: Are we alone? ⬣