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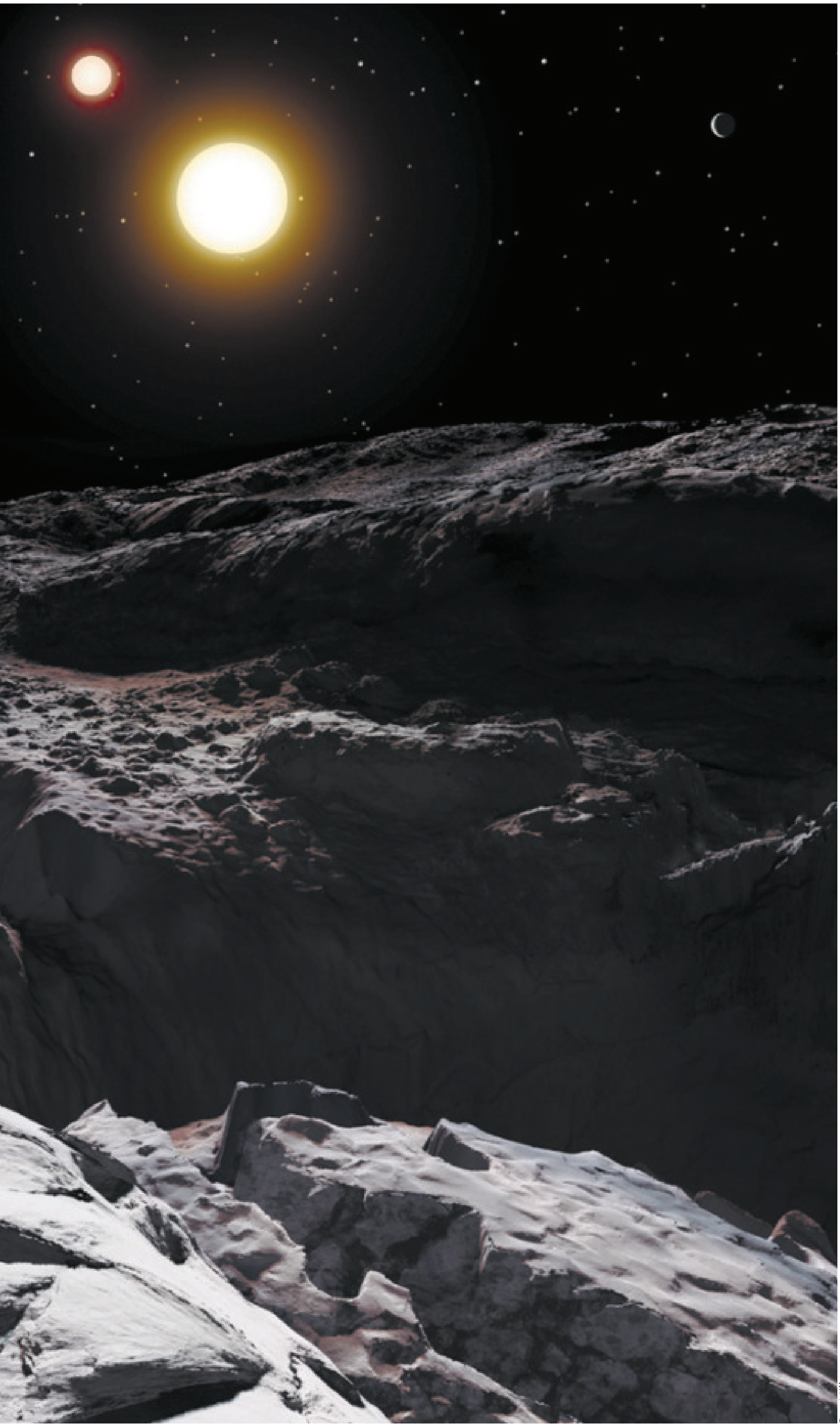
ADVANCES

An imagined view from the Kepler-16 planetary system


Ron Miller

PLANETARY SCIENCE

Order from Chaos

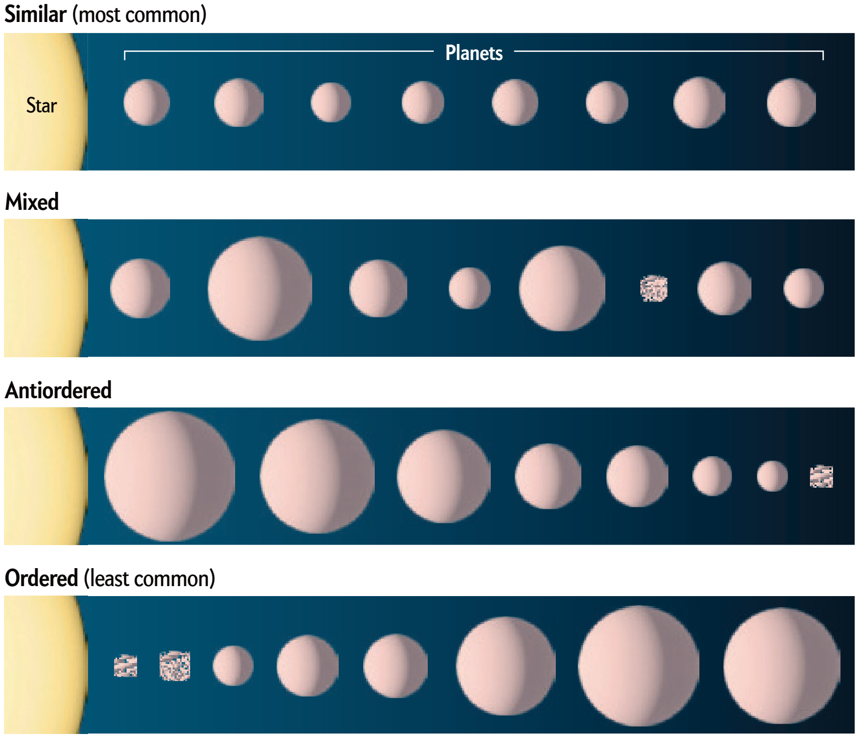
We live in the rarest type of star system

A planetary system is shaped at the boundary of order and chaos. It starts out as a molecular cloud—a big, cold clump of mostly hydrogen gas that can collapse to make stars. As central stars form, the remainder of the cloud flattens into a whirling protoplanetary disk that weaves together worlds from turbulent swirls of gas, ice and dust. From there larger-scale chaos can ensue as bigger planets push smaller ones around. The giant planets brawl among themselves, too, competing to rake up excess material and grow more giant still, sometimes ejecting the unlucky losers from the system in a "last planets standing" melee.

Scientists had long thought our own solar system—an "ordered" arrangement of tiny orbs closer to the sun and big ones farther out—was a typical outcome of this complex process. But NASA's planet-hunting Kepler mission revealed that most systems don't resemble our own at all, instead having "similar" configurations of closely packed worlds all nearly the same size and mass, like peas in a pod.

This disparity inspired astrophysicists

The Four Classes of Planetary Systems



Source: "Framework for the Architecture of Exoplanetary Systems," by Lokesh Mishra et al., in *Astronomy & Astrophysics,* Vol. 670; February 2023

Lokesh Mishra, now at IBM, Yann Alibert of the University of Bern and their colleagues to investigate what other architectures might exist. This is a formidable task for modern telescopes but a question that computer models can easily explore. Through their research they noted a third system type in the observational data—a "mixed" distribution of shuffled small and large planets—and their simulations predicted one more: an "antiordered" architecture of worlds that get smaller and less massive the farther they are from their star. These findings, which appear in two studies in *Astronomy & Astrophysics,* reinforce the conclusion that similar architectures are most common and suggest that ordered systems like our own are the rarest. "In a few years, I believe, we'll have something like a 'standard model' of planetary formation," Mishra says. "And how different architectures of planetary systems emerge is a question that any standard model will have to answer."

Crucially, this research introduces a new mathematical framework for quantifying similarities among a system's planets according to any observable characteristic, such as mass or size; one number reveals the total range of values for that characteristic among the planets, and the other reflects how widely those values typically vary from planet to planet. This can help uncover patterns that reveal broad rules governing the birth and growth of planetary systems—as well as where those orderly rules break down. Matching their model's predictions to observations suggests, for instance, that similar systems' pea-pod planets emerge from sedate, low-mass protoplanetary disks, with higher-mass disks more easily making big planets—like our own system's Jupiter—that can chaotically interact to yield the three other architectures. The powerful James Webb Space Telescope and other facilities may soon be able to test some of these ideas.

University of Chicago astrophysicist Daniel Fabrycky, who was not involved with the new research, says such upcoming observations make these kinds of studies especially valuable. "This is about building some set of concepts, around which we expect to be able to make interesting conclusions in the future," he says. "And that's always a good idea because it's more scientifically robust to make predictions and then check them, rather than observing surprising things and painting on a theoretical gloss afterward." *—Lee Billings*

MATERIALS SCIENCE

Soft Conductor

Squishy snail robot shows off a new kind of electronics

Sometimes science advances at a snail's pace, but in this case that's a good thing: researchers have created a squishy material that combines polymers with liquid metal, demonstrated in a snail-like robot. Developers say this electrically conductive gel could be used to make self-healing electronic circuits and biological monitors for measuring heart and muscle activity—and maybe even lead to robot nervous systems.

The composite substance is stretchy and soft like living tissue. If it breaks or tears, the edges can be touched together to quickly re-form the material's molecular bonds without any additional heat or chemical treatment. And crucially, its developers say, it is the first such material that also conducts electricity well.

These abilities could lead to wire-free medical monitors as well as fully soft robots. "For my research, one thing that's really big is, 'How do you put mul-

ANIMAL BEHAVIOR

Smells Like Victory

Wall lizards size up their opponents using odor alone

In a world full of fierce competition, gathering intel on opponents is a matter of life or death. One common reptile called the wall lizard uses a particularly clever tactic to sniff out fights it can win—literally. A new study shows that these lizards, which can reach eight inches long and live in Europe and North America, manage to estimate a competitor's size based on chemical scent cues alone.

Male wall lizards, like many geckos and iguanas, secrete a waxy fluid from pores in their inner thighs to mark their territory. Rival lizards can smell these chemicals, called femoral secretions,

Graphic by Amanda Montañez