Mass Meeting

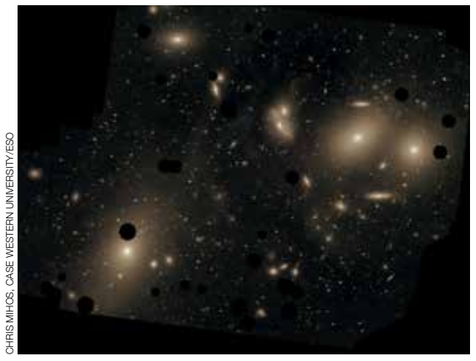
Once held to be illusory, superclusters of galaxies are now being defined.

The Milky Way has a new address. For six decades it's been known that our galactic home is perched at the edge of a long and vast collection of galaxies called the Virgo Supercluster. But an international team of astronomers recently announced that we belong to an even larger assembly in this sector of the universe. Led by R. Brent Tully of the University of Hawaii at Manoa, the team dubbed this gargantuan structure "Laniakea," which means "immense heaven" in Hawaiian.

This finding proves, once again, that galaxies are very sociable creatures. Even though space-time is continually stretching, moving most galaxies away from one another as the universe expands, gravity keeps adjacent neighbors together, even drawing them closer, forming arrangements across a range of sizes.

The Milky Way, for example, is part of a small collection right here in our galactic neighborhood. Edwin Hubble named it (rather uninspiredly) the "Local Group." One end is anchored by our home galaxy, surrounded by a bevy of dwarf galaxies; the Andromeda and Triangulum galaxies dominate the other end, with their own small companions. But the Local Group pales in comparison to the richest clusters. The Coma cluster, located some 300 million light-years away in the direction of the Coma Berenices constellation, contains thousands of galaxies hovering together like a dense cosmic flash mob.

Even before astronomers knew that many of the nebulae they were observing all over the heavens were distant galaxies, they noticed how some crowded together. In the eighteenth century astronomer William Herschel wrote about Coma's "remarkable collection." Having built the largest telescopes in his time, he was able to spot this prominent swarm more than two centuries ago.



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View toward the Virgo Cluster, the large galaxy cluster closest to our small Local Group, shows the diffuse light between the galaxies. The cluster includes an estimated 1,300–2,000 galaxies, from huge elliptical and spiral one to many dwarfs. The dark spots indicate where bright foreground stars were removed from the image.

But how far did this tendency go? Were there also, astronomers asked, *clusters* of galaxy clusters? That question took quite a while to answer. In the 1930s, both Harvard astronomer Harlow Shapley and the Swedish astronomer Erik Holmberg spoke of "metagalactic systems" or "metagalactic clouds," what we today call superclusters. To these observers' eyes, some of the clusters appeared to form even larger assemblies.

But, around the same time, Hubble photographed selected regions of the sky and concluded the opposite: that clusters were distributed fairly uniformly across the heavens. Hubble embraced the cosmological principle, the idea that on the very largest scales the universe must be "isotropic"—smooth and homogeneous as a fast-food milkshake. To him, galactic groupings stopped at clusters. This view was so strong that few dared to question it, and Hubble's opinion prevailed for many years . . . until a feisty French astronomer began to alter that widely held belief.

During World War II in France, astronomer Gérard de Vaucouleurs had been an expert observer of Mars, but by the early 1950s he had traveled to Australia to work at the Mount Stromlo Observatory. There he performed a tedious yet very important chore: a revision of one of astronomy's bibles, the Shapley-Ames catalog of bright galaxies. It changed his professional life. While updating the catalog's listings to include Southern Hemisphere galaxies, he couldn't help but notice (with the aid of his telescope) that the Milky Way, along with its Local Group neighbors, is caught on the outskirts of a much larger system of galaxies. Altogether this system is generally arranged as a flat disk, made up of multiple clusters of galaxies. On a celestial map, it appears as a long band that stretches across both the northern and southern skies. The Virgo cluster, a huge collection of hundreds of galaxies located some 65 million light-years away, serves as the disk's centerpiece.

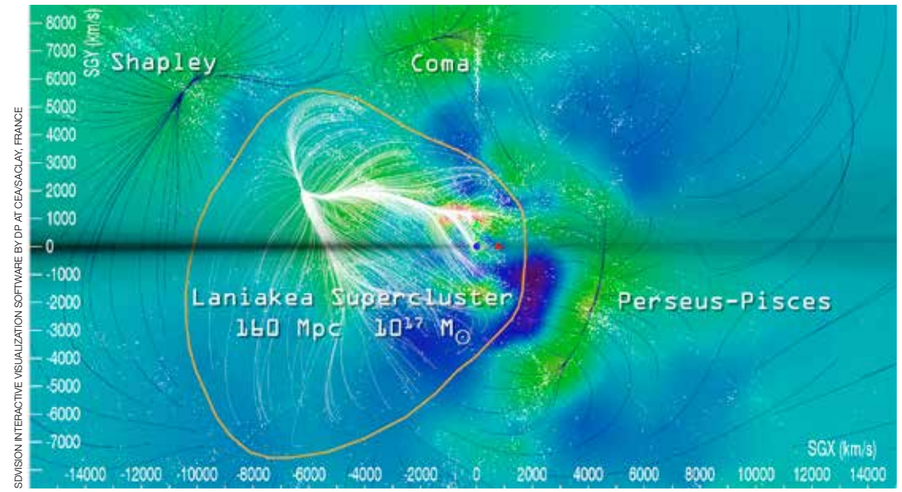
De Vaucouleurs was seeing what Holmberg and Shapley had already noticed, but he was more tenacious. In a 1953 scientific paper, he gave this grouping a distinct name. He called it the "Local Supergalaxy," what later became known as either the Local or Virgo Supercluster. In the 1980s de Vaucouleurs recalled that his suggestion was largely received with resounding silence. "It was considered as sheer speculation, even nonsense," he told me. "Some prominent astronomers even told their students that it was an insane topic to work on. The concept that the universe was isotropic was too strong. It was dogma."

But a few listened and gradually examined the idea further. More and more evidence piled up as other astronomers began to carry out their own surveys of galaxies across the heavens, with new instrumentation that enabled them to find both nearby and distant clusters that were once too faint to be counted. "All of a sudden," wrote Italian astronomer Andrea Biviano in a review of this history, "researchers had a catalogue of clusters, and they could start to look at them as a population, rather than as individual objects."

By 1961 the Local Supercluster was not alone. That year UCLA astronomer George Abell, the most noted cluster hunter of his era, examined all the data gathered so far by both him and others and pointed out other potential superclusters, each "large cloud" stretching up to 160 million light-years from end to end. Abell counted seventeen more in the nearby universe. As for the Local Supercluster, Abell declared that an independent survey found "striking confirmation of de Vaucouleurs' hypothesis."

But acceptance did not come readily. No one could yet explain how such large structures could remain stable over the eons. More than that, some astronomers wondered if they were being deceived? Our eyes are very sensitive to patterns, a trait that enabled our ancestors to spot a predator amid the jungle foliage. For a long time, many were wary that supercluster proponents were merely tracing out shapes in a random distribution of clusters, much the way early planetary astronomers found "canals" on Mars.

Starting in the 1980s, however, as astronomers were able to determine the distances to more and more galaxies and clusters, they produced three-dimensional maps of the heavens. They discovered they weren't being fooled at all. In fact, the distribution of galaxies was more astounding than they had imagined. Galaxies appear to congregate as if they are on the surfaces of huge bubbles, with the bubble interiors nearly devoid of galaxies. Evidence suggests that this cosmic foam originated in the Big Bang, owing to perturbations surging through the primordial soup.



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A slice of the Laniakea Supercluster through its equatorial plane: Gravitational flow streams within the region dominated by Laniakea are shown in white, with their outer limits outlined in orange. The small arrows originating at the black dot indicate the X and Y coordinate axes, centered on our Milky Way galaxy (the horizontal black shaded region indicates where our Earth-based view is obscured by the plane of the Milky Way). The colors represent density within this slice, with red for high densities, green for intermediate, and blue for areas with relatively little matter. Dark blue lines indicate the gravitational flow streams toward other, neighboring superclusters.

Filamentary superclusters stand out where the bubble-like surfaces intersect. At the time of de Vaucouleurs's death in 1995, many of these superclusters were well mapped, with astronomers naming them after the constellations in which they can be found, such as Coma, Leo, Hercules, Perseus-Pisces, and Centaurus.

And these superclusters are not static. That's how Tully and his colleagues found Laniakea. They saw that the Virgo Supercluster is being gravitationally drawn, like a river flowing downhill into a larger sea, toward a dense collection of galaxies known as the "Great Attractor." By tracing the movement of galaxies directed toward the Great Attractor, they could define the borders of the new Laniakea supercluster. An illustrative video of this flow can be viewed at vimeo.com/104704518.

Home to some 100,000 galaxies, Laniakea stretches more than 500 million light-years across, nearly five times larger than our original Virgo abode, now a mere branch. Formerly caught in a supercluster suburb, the Milky Way finds itself in Laniakea's hinterlands.

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