A Flower in Virgo

A 9-year survey has produced the first detailed maps of the Local Supercluster, providing new evidence about how the universe evolved

The northern galactic hemisphere—that portion of the sky lying to the north of the Milky Way—is rich in bright galaxies; the southern hemisphere is relatively barren. For a generation or more, astronomers have debated why. Their consensus today is that our galaxy lies at the edge of a much larger assemblage of galaxies, a structure some 60 million light-years across. They call it the Local Supercluster. The northern galactic hemisphere appears overpopulated because our own galaxy happens to lie almost face on to the supercluster core.

The core itself is a swarm of galaxies lying 50 million light-years from the earth in the direction of the constellation Virgo. Some 60 luminous galaxies and hundreds of not-so-luminous galaxies are contained there within a spherical region no more than 10 million light-years across. (A similar volume centered on the Milky Way contains just two large neighbors, the spiral galaxies in Andromeda and Triangulum.) One of the Virgo galaxies, the elliptical giant M87, ranks among the largest and most luminous such objects known; many astronomers suspect that it harbors a black hole at its center several million times more massive than the sun. The cluster as a whole is so massive that its gravity affects the motion of everything around it—including the Milky Way, which is known to be falling in the general direction of Virgo at several hundred kilometers per second.

According to new maps prepared by R. Brent Tully of the University of Hawaii and J. Richard Fisher of the National Radio Astronomy Observatory in Green Bank, West Virginia, the Virgo Cluster contains about 20 percent of the galaxies in the supercluster. A band of galaxies scattered across the sky to the north and south of Virgo contains another 40 percent. The final 40 percent lie to either side of the band in long, streaming clouds running outward from the core. When Tully and Fisher plot these galaxies as seen on the dome of the sky, the cluster, the band, and the streamers resemble nothing so much as a giant, many-petaled flower.

Tully and Fisher's maps, prepared after 9 years of measuring the positions and redshifts of some 2200 individual galaxies, are the first to show the supercluster in three dimensions. They use Hubble's law, which states that redshift is proportional to distance, to derive each galaxy's position in space. Their work will be published in the 1 June 1982 *Astrophysical Journal*. The maps reveal a surprisingly rich, convoluted structure that provides new evidence about how galaxies, clusters, and superclusters formed throughout the universe.

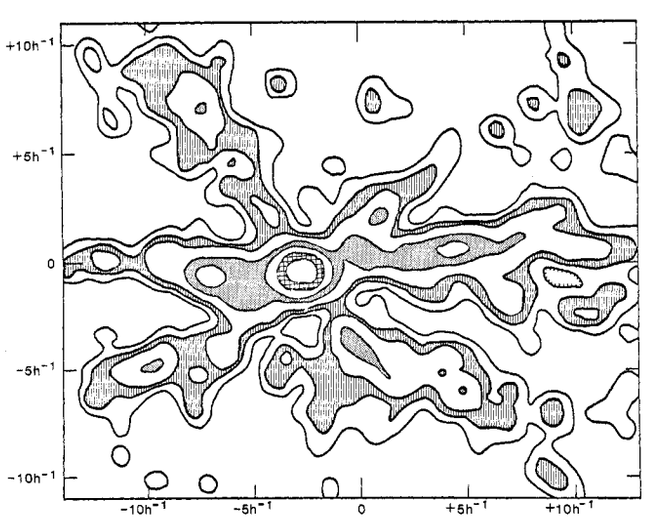
In the third dimension, the new Tully-Fisher maps resolve the band into a pair of sprawling, flat, irregular clouds. The one to the north they call the Canes Venatici cloud; the one to the south, the Virgo II cloud. Together with the cluster these clouds define a disk about 6 million light-years thick. The Milky Way and its neighbors (the Local Group) lie in the plane of the disk near the outer end of a filament of the Canes Venatici cloud. The "streamers" above and below the plane are thin, cigar-shaped clouds with their axes pointed toward the supercluster core in Virgo.

The most remarkable thing about all this, says Tully, is that so much of the supercluster is empty space: 98 percent of the luminous galaxies are contained in just 11 clouds, which together fill only 5 percent of the available volume. He is the first to admit that the three-dimensional maps may err considerably in detail—the redshift-distance proportionality (the Hubble parameter) is uncertain by as much as a factor of 2, for example, and the proper motion of the Milky Way toward Virgo biases the distance estimates by a similar factor—but the qualitative picture is incontrovertible.

It is also remarkable that the disk is quite thin, he says. The ratio of width to thickness is about 6 to 1. Moreover, the random motion of the galaxies along the line of sight seems quite small, less than 100 kilometers per second. For comparison, our own sun is orbiting the center of the Milky Way at some 220 kilometers per second.

Tully is convinced that the clouds above and below the disk were stretched into their current shape by the tidal action of the Virgo Cluster itself. The tidal forces operating today are much too weak to do that, he concedes; the clouds are tens of millions of light-years away from Virgo. But in an earlier epoch, before the universe had expanded to its present size, the clouds were much closer and the tidal forces correspondingly stronger. Tully estimates from this that the elongated clouds must have formed when the universe was about 1 billion years old. (Estimates of its current age range from 10 billion to 20 billion years.)

The existence of the supercluster disk implies one of three things, says Tully. One possibility is that the galaxies of the supercluster were much more widely scattered in the beginning, and that their current distribution in a disk is the result



Tully and Fisher here plot the density of galaxies in the supercluster as projected onto a plane that approximates the plane of the sky. The Virgo Cluster is apparent in the center. The supercluster disk, seen edge on, extends to the left and right. Distances are marked in millions of parsecs (a parsec is 3.26 light-years). The factor h^{-1} *denotes the uncertainty in the Hubble parameter; it lies between 1 and 2.*

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Almanac's Forecasts Questioned

Anyone can make a mistake forecasting the weather, even the venerable *Old Farmer's Almanac*. Its forecast of a mild mid-January this year for the East and South, when those areas suffered record cold, might be explained away as a fluky miscalculation. But the *Almanac* seems to have a consistent record of erroneous forecasts. A recent study by two weather researchers suggests that you would not do much worse by blindly guessing about the weather than by accepting the *Almanac*'s forecast.

Professional forecasters have long voiced serious doubts about the *Almanac*'s predictions. Calling for "mostly clear, turning hot" between 8 and 14 October 1982 in the Middle Atlantic states is such an absurdly detailed long-range forecast that most scientists think such prognostications useless. Even the monthly forecasts of deviations from normal temperature and precipitation seem overly ambitious. The *Almanac*'s forecasting methods are hardly conventional either. "A secret weather-forecasting formula devised by the founder of this almanac in 1792" has traditionally formed the basis of predictions, according to a statement in this year's edition. Recently the *Almanac*'s chief forecaster has come to depend primarily on "predicting the variation of solar activity and then determining the orientation of the earth relative to that activity."

Whatever the details of the forecasting method, the results for one 5-year period differ little from guessing, according to John Walsh and David Allen, who are research meteorologists at the University of Illinois in Urbana. Allen had become weary of hearing uncritical remarks from farmers about the accuracy of the *Almanac*'s forecasts, so he and Walsh compared 60 monthly forecasts from 1975 to 1980 with the actual weather.* Using the records of 32 cities to describe the weather in the *Almanac*'s 16 forecast regions, they calculated a mean correlation between predicted and actual temperatures of .016. For precipitation forecasts, the correlation was .041. If the predictions had been perfect, which the *Almanac* has never claimed, the correlations would have a value of 1.000; random guessing would produce a correlation of zero. The *Almanac* correctly predicted whether the temperature or precipitation would be above or below normal 52 percent of the time, Walsh says. A coin toss would succeed 50 percent of the time.

Contrary to the *Almanac*'s claim, long-range forecasts that are more successful are made, although they are not made so far in advance. Donald Gilman, head of the National Weather Service's long-range weather-forecasting group, reports that their monthly and seasonal forecasts of temperature are correct about 65 percent of the time in winter and about 60 percent year-round. Precipitation forecasts, on the other hand, exhibit "marginal" forecasting skill. They have a success rate of only 55 percent, he says.

Interestingly, the *Almanac* fared best in its own backyard, achieving seasonal temperature forecast correlations of .47 to .62 in the northeastern states. Even these higher correlations could result simply from a few lucky forecasts over the relatively short 5-year span, Walsh says. A longer sampling period would be needed to rule out the presence of any forecasting skill whatsoever, he notes.

Even if the *Almanac* does not measure up to the modest achievements of conventional long-range forecasting, could it be predicting some of the major weather extremes that stand out in the weather record? Walsh and Allen's comparison of a dozen periods of extreme weather with the *Almanac*'s predictions revealed only three cases in which the *Almanac* anticipated even the type of abnormal weather; in no case did its forecast approach the severity of the actual weather.

The most reliable *Almanac* forecast is the one-page, essay-style national forecast, according to Jud Hale, editor of the *Almanac*. It has been correct in a general way for the past dozen winters, he says. The rub is that, as Hale readily concedes, this forecast is too subjective to be verified statistically.

—RICHARD A. KERR

*"Testing the *Farmer's Almanac*," *Weatherwise* **34**, 212 (October 1981).

of random motions and mutual gravity. But such a configuration would be relatively short-lived, says Tully. He finds it difficult to believe that we just happen to be observing the supercluster at a special moment. Besides, such a model implies that the galaxies should have large velocities perpendicular to the disk, which seems inconsistent with the small random velocities observed along the line of sight, in the plane of the disk.

A second possibility is that the visible galaxies are held within the disk by the gravity of an immense plane of dark, invisible matter. This is not just science fiction. Such dark matter is found in halos around the individual galaxies (including our own) and as an all-pervasive medium within clusters of galaxies (including Virgo). But this model would tend to predict large random motions for the disk galaxies, which again seems inconsistent with the observations, says Tully.

The low random velocities along the line of sight lead Tully to support the third possibility: that the disk, like the Virgo Cluster and the streamer clouds, is nearly as old as the universe itself. It has not dissipated simply because the individual galaxies are moving too slowly to escape.

This model is also in accord with one of the major theories of the origin of structure in the universe, the "pancake" model of Ya. B. Zeldovich and his colleagues in the Soviet Union. Their idea is that the large-scale structure began to form very early in the life of the universe, long before there were galaxies. Clumps of primordial gas on the order of 10^{13} solar masses or larger—supercluster size—began to collapse by their own internal gravity. Because of random deviations from spherical symmetry, they tended to evolve into sheetlike structures, resembling pancakes. Turbulence, viscosity, and shock waves then dissipated the kinetic energy of the infalling gas and the pancakes stabilized. Only later did the galaxies form. The model thus predicts a structure very much like what is seen in the Local Supercluster, says Tully.

The observations are less favorable to a major alternative model, the gravitational clustering picture promoted in recent years by P. James E. Peebles of Princeton University, and others. Their idea is that the galaxies formed first in the early universe, and only then began to cluster. The problem is that this model has no way to dissipate kinetic energy. In the immensity of space the galaxies are very small. They almost never collide. If by chance they formed a thin

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sheet they would quickly move apart again. So it is difficult to see how gravitational clustering alone could have produced the kind of structure seen in the Local Supercluster, says Tully.

Testing these ideas in more distant superclusters is more difficult, he says. Outside our own neighborhood, individual galaxies cannot be located accurately enough in the line of sight to know whether they lie on the front side or the back side of their supercluster. Moreover, the dim galaxies, which actually outnumber the bright ones, are undetectable at great distances. It is only in the local supercluster that the census can be relatively complete.

None of the models of large-scale structure is without its problems in any case, notes Tully. Most important, none of them can explain where the initial density fluctuations came from. So in an ultimate sense, no one really knows why the Local Supercluster exists. But at least, he says, we are learning how to formulate the questions that address the problem.—M. MITCHELL WALDROP

Gene Transfer Yields Cancer Clues

Some cancer cells carry genes that transform cultured cells. Researchers are beginning to isolate and clone the transforming genes

Using gene transfer techniques, investigators have recently shown that cultured cancer cells derived from human and animal tumors often carry transforming genes that cause normal cells to acquire cancerous characteristics. The experiments provide direct support for what everyone has thought all along, namely that gene changes contribute to the development of many cancers. But they do more than that. For the first time, researchers are gaining the ability to isolate, clone, and study in detail transforming genes from cancers that have arisen spontaneously or been induced by chemicals.

Substantial progress has already been made in identifying the transforming genes carried by many of the viruses that cause cancers in animals. Studies of these genes, which are called *onc* (for oncogenic) genes, are providing much information about the biochemical basis of viral transformation, and possibly about transformation in general. Nevertheless, the applicability of the viral results to the problem of human cancer remains to be proven.

As Robert Weinberg of the Massachusetts Institute of Technology (MIT) points out, "Hopes of finding viral agents that cause human cancers have largely been frustrated." Even though viruses have been implicated as the cause of some, mostly rare, forms of cancer, Weinberg continues, "In general, it is likely to be the case that the cancers common in this country are not going to have a viral etiology. If it is not a viral agent, then what kinds of changes in the cell are causing cancer?"

The evidence suggesting that they are gene changes includes demonstrations by Bruce Ames of the University of California at Berkeley and others that radiation and chemicals that are carcinogenic are usually mutagenic, effecting alterations in DNA. In the past, investigators were not able to identify the affected genes because they lacked probes that could pick them out from among the many tens of thousands present in a mammalian cell.

With the normal road to gene isolation blocked, investigators, including Weinberg and Geoffrey Cooper of the Sidney Farber Cancer Institute and Harvard Medical School, turned in the late 1970's to "transfection" methods, gene transfer techniques that have developed rapidly in recent years (*Science*, 19 December 1980, p. 1334). As long as the transferred gene confers some detectable new property on the recipient cells, the methods provide an assay for its presence that can be used in lieu of a more conventional probe. Acquisition of a transforming gene, for example, should alter the growth pattern and shape of the recipient cells in a characteristic fashion.

In an early series of experiments, Chiaho Shih of MIT and Weinberg transferred DNA prepared from each of 15 different lines of mouse cells that had been transformed with chemical carcinogens to mouse cells (fibroblasts) of the NIH3T3 line. The results suggested that some of the lines carried a transmissible transforming gene. Shih, Weinberg, and their collaborators found that DNA from five of them, all transformed by 3-methylcholanthrene, caused the recipient cells to be transformed at a frequency 10 times higher than the frequency of transformation by DNA from normal cells. Weinberg says, "The DNA from transformed cells functioned differently from the DNA of normal cells. It carried transforming sequences."

The transforming trait appeared to be carried on a single fragment of DNA. "The behavior of the DNA suggested that the transforming activity was located in a single discrete segment," Weinberg explains. "It was incompatible with a series of genes scattered through the genome acting together to create this phenotype." Even in the best cases, the efficiency of gene transfer is low, only about one in 100,000 cells successfully acquiring a new gene. Since the probability of transferring one gene is low, it is mathematically unlikely that two or more unlinked genes will be transferred.

In more recent experiments, DNA's from a variety of cell lines derived from human cancers have been found to transform NIH3T3 cells. Weinberg's group found this to be the case for lines derived from colon and bladder carcinoma cells and from promyelocytic leukemia cells. Cooper and Theodore Krontiris of the Sidney Farber Cancer Institute obtained transformation with DNA's from two lines of bladder carcinoma cells. In collaboration with Mary-Ann Lane, who is also at Sidney Farber, Cooper transformed NIH3T3 cells with DNA from a line of mammary carcinoma cells, as well as with DNA's from a number of kinds of malignant human lymphocytes. And Michael Wigler and Manuel Perucho of the Cold Spring Harbor Laboratory obtained similar results with DNA's from two lines of lung carcinoma cells and one line each of bladder, colon carcinoma, and neuroblastoma cells.

Explaining transformation might have been simplified if all these cell types turned out to have the same transforming gene. That did not happen, although cancers of a particular cell type may be traceable to the activation of a specific transforming gene. According to Weinberg, "The hypothesis, which is becoming increasingly validated, is that each given type of tissue will have a characteristic activated oncogene." Investiga-

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