tirety, which precluded direct tests of his hypothesis. Attitudes and regulations about data sharing have changed since 1975, so all of the participants in the favored states debate at least are working with the same data sets.

The volume's most worthwhile contribution is by J. Bastow Wilson. He tersely presents a catalog of currently proposed assembly rules and describes the null models that have been used to test them. Drawing on his own studies of the assembly of plant communities, Wilson also discusses how environmental heterogeneity can obscure assembly rules and suggests some creative solutions to that problem. This chapter is the single best overview of the state-of-the-art in community assembly rules.

No major syntheses or breakthroughs emerge from this volume. But it does a good job of illustrating the increasingly sophisticated use of null models to test community patterns. Twenty five years after their publication, Diamond's ideas on assembly rules are still being studied and debated. *Ecological Assembly Rules* highlights many facets of the current research program.

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PERSPECTIVES: VOLCANISM

Will Vesuvius Erupt? Three Million People Need to Know

Grant Heiken

The Bay of Naples and the adjacent Campanian Plain are rich, the seaside beautiful, and the weather mild. During the time of the Roman empire, this region was a prime location for holiday villas, and during the 18th and 19th centuries, Naples was a required destination on the "Grand Tour" for well-educated, wealthy youths. But the region has also been the site of devastating volcanic eruptions, most notably that of 79 A.D., which buried the thriving Roman town of Pompeii. Today, close to 3 million people live in the volcanic areas around Naples, 1 million of them on the slopes of Mount Vesuvius. Historic and geological records and seismic monitoring networks are now providing insights into the patterns of volcanic activity and may help mitigate the hazards of future eruptions.

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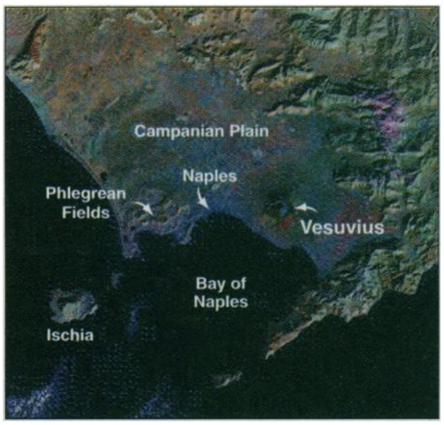
Neapolitans are well aware of the area's volcanic heritage and are periodically reminded of the potential danger under which they live. In 1982–84, ground uplift and earthquakes in the Phlegrean Fields (see the figure on this page) resulted in the evacuation of thousands of residents from the nearby city of Pozzuoli. When the uplift and seismic activity ceased, the political response was violent and chaotic, including accusations aimed at the scientists for "crying wolf." But after the events in the Phlegrean Fields, the Italian National Research Council's National Group of Volcanology and the Ministry for Civil Protection expanded their research effort to better understand the eruption histories of Neapolitan volcanoes. Improved monitoring systems at the Osservatorio Vesuviano (OV) (*1*) were established, along with an intense educational campaign focusing on volcanic eruptions and associated hazards for the region's cities. Scientists are asked tough questions by the public, such as, when will Vesuvius erupt? How will it erupt? And which areas will be affected? These questions are extremely difficult to answer and are best addressed by studying past eruptions and establishing an integrated monitoring network.



Satellite image of the Bay of Naples.

Volcanologists from the OV and the Universities of Naples and Pisa have used data from outcrops and drill holes to evaluate the Plinian (explosive) and Strombolian (lava fountains and lava flow) volcanic activity in the area of the Bay of Naples that began 126,000 years ago. During the past 19,000 years, seven Plinian eruptions have occurred, at 18,300, 16,780*, 8010, 3360, 1920 (79 A.D.), 1527*, and 368* years before the present (an asterisk denotes smaller scale Plinian eruptions) (*2–4*). These eruptions each produced between 5 and 11 km^3 of volcanic ash and pumice that were deposited as fallout or fast-moving density currents known as pyroclastic flows or surges. Each eruption devastated an area of 20,000 to 30,000 hectares, and some of the currents extended as far as 22 km beyond the crater. Plinian eruptions pose the greatest hazard to people living on or near Vesuvius because the 600°C density currents are capable of flattening 3-m-thick stone walls 10 km from the vent. In almost all of these explosive eruptions, exsolution of gases from rising magma was followed by pressure release within 2 km of the surface, magma fragmentation, and eruption. As the eruption progressed, the fragmentation process was enhanced when water and magma mixed in limestone aquifers underlying the volcanic and sedimentary deposits of the Campanian Plain (see the figure on this page). Thermally altered fragments from the limestones were also erupted, indicating that increased explosive fragmentation, perhaps associated with magma/water mixing, occurred below a depth of 2 km. At the same time as the Plinian eruptions, a caldera (collapse crater), now called Monte Somma, was formed.

Since 79 A.D., Strombolian activity has constructed the summit cone that today partly fills the Monte Somma. Periods of Strombolian activity—more common than Plinian eruptions yet less dangerous—have occurred frequently since 1631 A.D. (see the figure on the next page). There were 18 eruption cycles between 1631 and 1944 alone, ranging from 2 to 37 years, with repose periods of 0.5 to 6.8 years between cycles (*3*). Since 1944, Vesuvius has seen no activity except fumaroles in the summit crater. This unusually long repose period of 55 years may indicate dormancy or the quiet time preceding a Plinian eruption. To de-

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Past Vesuvian activity. This painting of the 1794 eruption as viewed from Naples is typical of Strombolian activity between 1631 and 1944.

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termine which, we must know if there is magma within the crust below Vesuvius.

Multiple geophysical surveys by 12 groups from the European Community culminated in the recent TOMOVES (Vesuvius tomography experiment) (*5–7*). These surveys included seismic surveys across the Campanian Plain (see the figure on the previous page) that were linked to seismic surveys in the Bay of Naples. The surveys verified an interface at a depth of 2 km between the limestone "basement" and a sequence of overlying volcanic rocks and marine sediments. Knowledge of this interface is important for identifying the depths of potential aquifers where magma/water mixing occurred and generated highly explosive activity. A high seismic velocity zone directly below the summit has been interpreted as a solid dike network left by past eruptions. A low-velocity zone, possibly a partial melt, has been tentatively identified at a depth of 10 km. Teleseismic events suggest the presence of low-velocity zones below Vesuvius at depths of 15 and 300 km. These data have helped geophysicists to understand the overall structure of the volcano but are insufficient to identify specific locations of magma bodies.

Prediction of volcanic activity is thus not possible yet. But multiple monitoring networks are in place should Vesuvius resume its volcanic activity. The OV's integrated geophysical network covers the volcano and surrounding plain and would provide the first indication of rising magma. Any ground deformation caused by rising magma would be detected by leveling, tiltmeter, Global Positioning System (GPS), and tide-gauge networks. Gas compositions at high-temperature fumaroles are continuously measured.

Over the past decade, no signs of volcanic activity at Vesuvius have been detected (*8*). But people living on or near the volcano cannot be indifferent. Around the globe, many supposedly dormant or extinct volcanoes have erupted in the past 20 years. Where local populations were well-informed about volcanic eruptions and their effects, timely evacuations saved lives. People living near Vesuvius need ongoing educational programs to accompany state-of-the-art monitoring and detailed research on the volcano's past activity.

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PERSPECTIVES: PROTEIN STRUCTURE

Molecular Rotary Motors

Robert H. Fillingame

The enzymes that synthesize adenosine triphosphate (ATP) in the mitochondria and chloroplasts of animal and plant cells, and in bacteria, are the world's smallest rotary motors. These enzymes, the F_1F_0 ATP synthases, provide the cell with its energy currency (ATP) by catalyzing the addition of inorganic phosphate (P_i) to adenosine diphosphate (ADP). The synthesis of ATP is driven by a proton electrochemical potential (the proton-motive force) generated across the bacterial plasma membrane (or mitochondrial membrane) by a chain of electron transport proteins. The ATP synthase is composed of an F_1 catalytic domain that projects into the cytoplasm of a bacterial cell (or into the mitochondrial matrix) and an F_0 domain that traverses the membrane (see the figure). This enzyme is able to reversibly couple the rotation of several of its subunits (mechanically driven by the proton-motive force) to the generation of the chemical bond between ADP and P_i. On page 1722 of this issue, Sambongi *et al.* define the molecular components of the rotary motor of bacterial ATP synthase (*1*), and on page 1700 Stock *et al.* present the general structure of the rotary unit in yeast mitochondrial ATP synthase, explaining how it interacts with the other components of the enzyme (*2*). Together these two reports provide a coherent structural explanation for the rotary mechanism of ATP synthesis.

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The F_1 domain of the *Escherichia coli* ATP synthase consists of five subunits (α, β, γ, δ, ε) in an $\alpha_3\beta_3(\gamma\delta\varepsilon)_1$ arrangement. The F_0 inner membrane sector is composed of three subunits (a, b, c) in an $a_1b_2c_{12}$ complex (see the figure). ATP synthesis is driven by rotation of the single γ subunit within a hexamer of alternating α and β subunits that contains three catalytic sites. As the γ subunit moves from site to site, it alternately promotes tight (ADP + P_i) substrate binding at one site and ATP product release at the next. The changes in binding affinities are cooperative, such that tight (ADP + P_i) binding at one site occurs simultaneously with ATP release at the next site.

This "binding change" mechanism was originally proposed by Boyer (*3*). An atomic-resolution x-ray diffraction structure of a bovine mitochondrial $\alpha_3\beta_3\gamma'$ subcomplex of the enzyme (where γ' is the segment of subunit γ resolved in the structure), published by Walker and colleagues in 1994, provided structural verification of this mechanism (*4*). In 1997, Noji *et al.* (*5*) directly demonstrated rotation of the γ subunit in the $\alpha_3\beta_3\gamma$ subcomplex. This water-soluble subcomplex hydrolyzes ATP in a reaction that is the reverse of ATP synthesis. Noji *et al.* immobilized the $\alpha_3\beta_3\gamma$ subcomplex on a microscope slide and decorated the protruding end of the γ subunit with a fluorescent actin filament. Upon addition of ATP to the immobilized enzyme, rotation of the fluorescent filament was observed directly with a microscope. Following this demonstration of rotary catalysis, the major question became the mechanism by which the proton-motive force drives rotation of the γ subunit. The favored hypothesis is that the proton-motive force drives rotation of an oligomeric ring of c

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