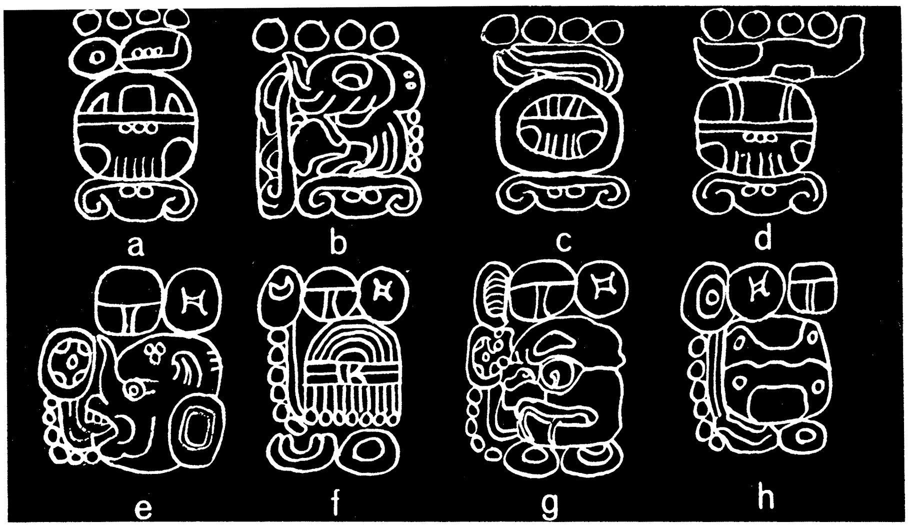
Ancient city planning on the Yucatan Peninsula

A map showing the sites of Mayan cities, towns and villages looks like a Buckminster Fuller scheme for the placement of population centers of the future. The highly structured settlement pattern, however, is not a vision of tomorrow but a reconstruction of yesterday. It is a result of the application of locational analysis to the civilization of the lowland Maya which reached its Classic peak between 600 and 900 A.D. on the Yucatan Peninsula.

An overall organization plan of the Maya lowlands shows that there were four regional capitals. Around each capital existed a hexagonal lattice of secondary centers. Tertiary hexagons developed around the secondary centers, and shifting villages and hamlets grew up around the tertiary towns. Theories have suggested that such geographical organization was developed as a defense system. The outer cities, for instance, would act as buffers to protect the major or core cities.

Joyce Marcus of Harvard University disagrees. She is currently engaged in Maya hieroglyphic research at the Dunbarton Oaks Center for Pre-Columbian Studies in Washington. From studies of Maya hieroglyphs and from locational analysis, Marcus concludes that the territorial organization of the Maya was based on their quadripartite view of the universe. She further concludes in the June 1 SCIENCE that the core-buffer theory is inoperative.

The Maya quadripartite model of the universe says that heaven is divided into four levels or regions. Each level is associated with a cardinal direction, color and god. Hell is similarly divided and, therefore, the Mayas divided the earth or their territory into four major areas. Each area had a ceremonial, religious, political and commercial capital. It is around such capitals that the



Drawings: Marcus/Science

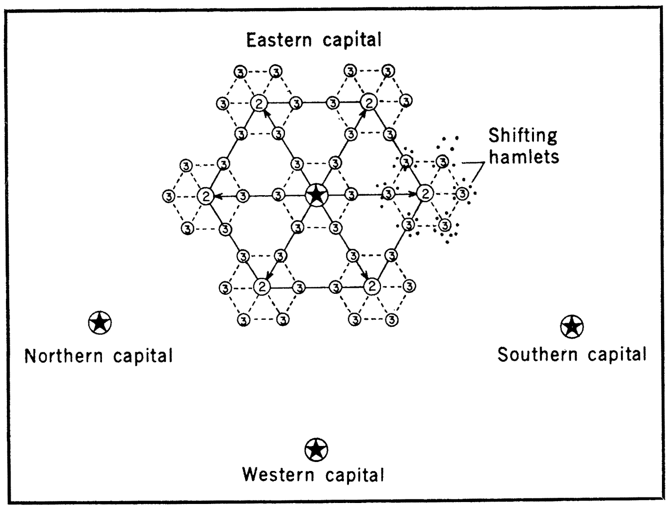
Maya hieroglyphic inscriptions relating to the four regional capitals.

hexagonal lattices developed. But they developed on a central-place theory, not a core-buffer theory, says Marcus.

According to the central-place theory, outlying cities or service centers are placed where they will ensure uniform distribution of population and purchasing power, uniform terrain and resource distribution and equal transport facility in all directions. All central places perform the same functions and serve areas of the same size. The most economical spacing of such service centers would be equidistant, resulting in hexagonal patterns. The Maya, however, did not recognize this pattern. They simply saw that a whole series of smaller centers were dependent on a primary center. In view of the geography of the area (irregular topography and seasonally flooded swamps), says Marcus, it is amazing how nearly uniform the spacing of such centers is. This suggests, she goes on, the degree to which the service functions of these centers strongly overrode such factors as good soil, water, shelter or defense.

Hieroglyphs found on *stelae* (free-standing, carved stone monuments) in the various cities help confirm her theory. Such hieroglyphs were once thought to be mainly astronomical and cosmological. It is now believed that many are records of ruling dynasties. Using such information Marcus notes that the four capitals apparently could mention each other by name (or hieroglyph), but no secondary center could mention a primary center except that to which it was subsidiary. This fact makes it possible to identify the various secondary centers dependent on a primary center. The *stelae* further indicate that the secondary centers and capitals were sometimes socially and politically linked by royal marriage alliances. A royal marriage often stimulated a flurry of monument carving.

Most surveys of Maya territory have concentrated on major centers. But as more information on minor centers and hamlets becomes available, Marcus hopes to complete her analysis of the social, political and territorial organization of the lowland Maya and confirm her theory. □



Idealized diagram of Maya hexagonal territorial organization with capitals, secondary and tertiary cities.

Evolution of a molecule: Code-breaking in the lab

Nucleic acids are the chemical molecules that contain genetic information. How primitive molecules evolved on the primordial earth into ever-more-complex nucleic acids is one of the more intriguing questions of modern biology.

During the past decade D. R. Mills, F. R. Kramer and Sol Spiegelman of Columbia University College of Physicians and Surgeons have arrived at a better understanding of how nucleic acids, specifically RNA molecules, probably evolved. Their most recent experiments, reported this week, should pave the way for an even better insight into the evolution of nucleic acids.

In 1965 the Columbia researchers

isolated from bacteria cells an enzyme that was part of an RNA virus known as the Q-beta virus. This enzyme could replicate the virus in a bacterium. The enzyme could also replicate the RNA of the virus outside a bacterium—in the test tube. They also found that the RNA molecules that were replicated by the enzyme in the test tube could be introduced back into bacteria as infectious agents.

This was the first time a nucleic acid had been replicated in the test tube instead of in a living cell. Because nucleic acids probably evolved outside cells before they became parts of cells, the test-tube replication of the molecules seemed likely to offer some important insights into how nucleic acids evolved.

So the Columbia researchers carried out further experiments in which Q-beta virus RNA molecules were reproduced in the test tube under various environmental conditions. A trillion molecules were replicated in 20 minutes, which represented thousands of years of natural evolution.

The researchers concluded several things from their evidence: that primitive nucleic acids had little trouble replicating themselves outside cells, and that they did so by selective alteration in their chemistry to meet environmental requirements.

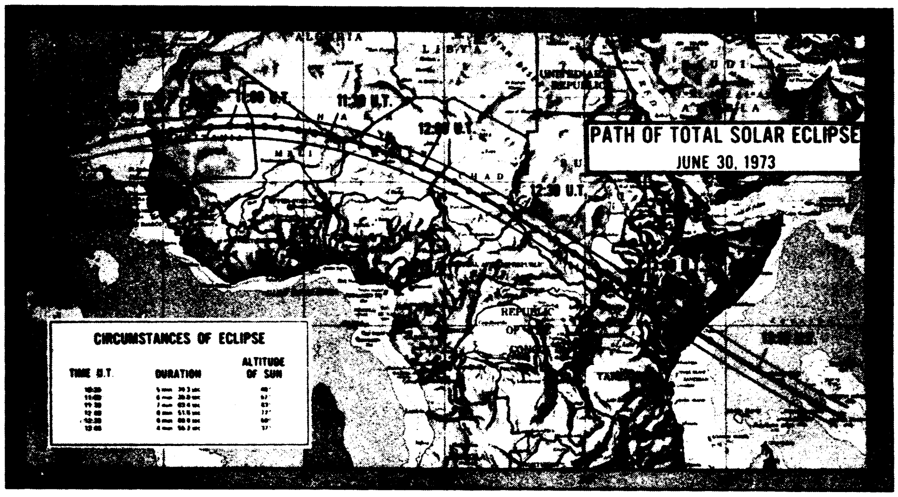
But other questions about the evolution of nucleic acids pressed for answers. What parts of the molecules were synthesized first? How did relatively simple nucleic acids evolve into ever more complex ones that would be capable of harboring the genes of viruses and cells? Why did some nucleic acid mutants survive, and not others? The Columbia team realized they would be able to answer these questions only if they determined the chemistry of a nucleic acid capable of replicating outside a cell.

They report in the June 1 SCIENCE that they have done just that. They have determined the exact sequence of the 218 nucleotides of an RNA molecule that comprises the genetic core of an RNA virus known as the MDV-1 virus. Like the Q-beta virus, the MDV-1 virus can reproduce itself outside cells.

The Columbia researchers are the first scientists to determine the chemistry of a nucleic acid that can reproduce outside the living cell. The achievement provides the first opportunity to study the mechanism of RNA replication in the test tube with a molecule whose chemistry is known in complete detail.

The advance, says Mills, "will enable us to study the chemistry of nucleic acid replication and to answer some of the really exciting questions about nucleic acid evolution." □

Stalking the coming solar eclipse in Africa



NSF

Not until 2150 will earthbound astronomers again see so long a solar eclipse.

Seldom is the sun better observed than when the moon hides it from view. On June 30 it will be thus hidden, as scientists from around the world gather on the land, sea and air of Africa to record its fleeting disappearance.

This solar eclipse will provide an enviable opportunity for scientists. Generations of their descendants will come and go before such a long one occurs again—177 years later, in 2150 (SN: 5/26/73, p. 340). Even in that distant future, the sun's longest banishment—seven minutes and fourteen seconds—will be visible only from a point in the northern Pacific Ocean, a less than desirable observation site. This year, however, fortunate sun-watchers will be able to cluster their telescopes, spectrometers, cameras and other instruments on firm footing for seven minutes and four seconds of totality near the border of Mali and Mauritania.

A few of the observers will be able to do even better than that. For the first time a supersonic aircraft, the Anglo-French Concorde, will be running with the sun, or rather with the moon, following the lunar shadow as it races across the earth at more than 2,000 miles per hour.

The flight will be a tricky one. Indeed, at least one observer feels that its greatest significance may simply be to prove that it can be done. Strong winds will tax navigation techniques for the 55,000-foot-high mission, and the path of the eclipse's shadow, 160 miles wide at its greatest, could be lost in seconds at the Concorde's speed. In addition, the vibration of sonic booms and the visual interference of jet exhaust trails must be kept away from the ground observers gathered along the same route. (Commercial aircraft have been requested to avoid the path during the eclipse.)

Aboard the Concorde, researchers from France, England and the United States will monitor the structure and dynamics of the sun's corona and chromosphere, with the plane's speed providing an unprecedentedly long look of as much as 85 minutes at the total eclipse. A shorter airborne expedition will be aboard a slower NC-135 aircraft from the U.S. Air Force's Cambridge Research Laboratory, looking particularly at coronal phenomena well out from the edge of the sun's disk. The highest look of all, if all goes well, may be provided by automatic cameras aboard the Apollo telescope mount on Skylab, even if the space station itself is between crews.

The earthbound observers face their own problems, ranging from the availability of electricity and fresh water to elaborate customs regulations. Numerous ground observations will be made, but many of them will not be focused on the sun itself. A German investigator plans to probe the possibility that a total solar eclipse is a source of gravity waves in earth's atmosphere. A U.S. team will take advantage of the darkened sun to search for a tiny planetoid that has been hypothesized for more than a century as a possible reason for movements in the perihelion of Mercury. French astronomers will use the lengthy totality enabled by the Concorde to measure the distribution of interplanetary dust. Other groups will study the eclipse's effects on radio transmissions, earth's magnetic field and the oxygen in the atmosphere.

Most unusual, perhaps, are at least four studies of the effects of the darkening sun on various primitive African tribes including one, the Borana near Ethiopia, who base most of their religion on the sun, yet reportedly are unaware that the eclipse is coming. □