ing compartments, or potential wells. Adjustable vertical barriers divide these wells in half. A particle loaded into, say, the left half of a well corresponds to 0 and into the right half to 1.

In the downhill loading step, an incoming bit (0 or 1) waits in its own well to meet a well returning from the top of the ski lift. This returning well is initially in the 0 state. If the incoming bit is 1, its well induces the barrier in the returning well to lower temporarily and forces the particle in the returning well to pass from the left to the right half. Then, the original incoming well is reset so the value of its bit is 0.

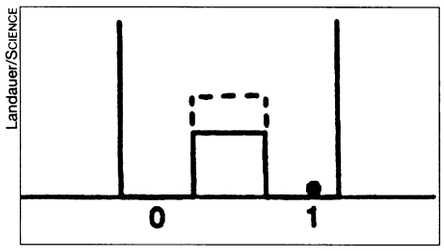
The freshly loaded well next travels back up the ski lift to the unloading area, where its bit is copied to a receiving well. The unloaded well is reset to 0 and returns downhill to repeat the information transfer cycle.

In principle, each of the operations involved in this scenario and in his other proposals involves no expenditure of energy, Landauer argues. Instead of getting thrown away, the bits are, in effect, recycled. Moreover, the basic setup does not require that the signals overcome background noise.

"These are not practical schemes," Landauer admits. They may, however, stimulate others to invent communication systems that make better use of energy than those now available.

For example, it may be possible to use the timing or angle of polarization of photons to achieve an effect similar to that underlying Landauer's quantum ski lift model of a communication link.

Even if his theoretical models are unachievable in practice, Landauer notes, it is still worthwhile knowing that no physical law prohibits extremely low energy communication. *— I. Peterson*



Potential well divided in two by an adjustable barrier, with a particle loaded into the right side to represent 1.

Romanian cave contains novel ecosystem

A cavern isolated from the rest of the world under a Romanian cornfield nourishes the first known ecosystem of its kind, three biologists report this week. The 48 animal species—including 33 new ones—found in Movile Cave are part of a food chain that draws sustenance solely from energy-rich molecules in rocks instead of from the power packed in the sun's rays.

Almost all life systems on Earth depend on photosynthesis—directly or indirectly—to fill their metabolic needs. Most animals that live only in caves rely to some extent on photosynthesis because they consume decayed plants swept down from the surface, says Brian K. Kinkle, a microbiologist at the University of Cincinnati.

Scientists have discovered other ecosystems that derive their energy purely from chemical sources, such as bacteria living underground (SN: 10/21/95, p. 263) or deep-sea communities that feed off mineral-rich hydrothermal vents. However, the Romanian cave is unique, Kinkle says, in that it contains the first known land animals not tied to photosynthesis.

The biologists analyzed the animals' diet by taking specimens of bacteria, fungi, and small invertebrates and comparing the ratios of four nonradioactive carbon and nitrogen isotopes. The results showed that the animals live on fungi and bacteria floating on water that partially fills the cave, Kinkle and his colleagues report in the June 28 SCIENCE. These microorganisms consume hydrogen sulfide from the rocks.

The scientists see Movile Cave as a biological time capsule. It was sealed off more than 5.5 million years ago, they say, and its creatures have evolved into specialized, self-sufficient forms. The only thing they need from above is oxygen, which leaks into the cave via minute cracks.

Thomas C. Kane, a biologist at the University of Cincinnati and report coauthor, said he was excited by "not just finding a new species—that happens every day—but finding 33 new species."

The discoveries include grazers such as four species of isopods, or pillbugs, six springtails, a millipede, and a bristletail. Among the new species of carnivores are two pseudoscorpions, a 2-inch-long centipede, a worm-sucking leech, four spiders, and a water scorpion.

That such a diverse community can feed itself in a cave's perpetual night is news to other scientists, too. Larry Lemke of NASA's Ames Research Center in Mountain View, Calif., says Movile qualifies as an excellent "Mars analog site."

Lemke works on the design of new missions to search for life on the Red Planet. Scientists now hold that life may have existed there 3.5 billion years ago, when the planet was warmer and wetter (SN: 8/27/94, p. 137). If that life still survives, it would have to be underground, where liquid water could exist, as it does in Movile Cave.

"Movile Cave is interesting because it seems to be truly closed to outside sources of organic material," notes Lemke. *— E. Skindrud*

Ancient world gets precise chronology

Scholarly debate and uncertainty have dogged efforts to specify precisely the years when various ancient civilizations thrived in the lands bordering the eastern Mediterranean Sea. An ongoing analysis of tree-ring evidence, described in the June 27 NATURE, promises to bring unprecedented exactitude to the calendar of ancient history.

New data from this project yield an exact chronology of eastern Mediterranean cultures from 2220 B.C. to 718 B.C., a time span that encompasses the rise and fall of early urban centers in Mesopotamia and Egypt, as well as the emergence of societies in Greece and Rome.

"Tree-ring dating now offers the route to a new, absolute chronology of the Old World that is independent of existing assumptions, gaps in evidence, and debates," asserts a scientific team headed by Peter Ian Kuniholm, an archaeologist at Cornell University.

Although this line of investigation will probably generate a reliable time line for archaeological sites in the eastern Mediterranean, doubts still remain about the dating sequence currently proposed by Kuniholm's group, writes Colin Renfrew of the McDonald Institute for Archaeological Research in Cambridge, England, in an accompanying comment.

Prior attempts to devise chronologies for early civilizations in the Near East and Egypt relied largely on recovered documents, such as clay tablets, which outline regional successions of kings and other royal figures. Three different chronologies have been proposed on the basis of such information.

Kuniholm and his colleagues aimed to calibrate a sequence of radiocarbon dates using tree rings from a variety of ancient timbers, most of which came from modern-day Turkey. They identified what they called a floating chronology of 1,503 years, a slice of time from around the second millennium B.C. that could not be pinned to exact years.

The scientists then obtained 18 high-precision radiocarbon dates from a juniper log at a Turkish archaeological site. A statistical comparison of these measurements to radiocarbon measurements from Europe and North America, all of which have established calendar dates, resulted in a chronological sequence for the eastern Mediterranean.

That estimate still contained a slight margin of error. Confirmation of the new chronology emerged with the observation at another Turkish site of exceptional growth in tree rings that correspond

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to comparably enlarged European and North American tree rings dated at 1628 B.C., the investigators contend.

Some kind of environmental disturbance produced a dramatically cooler, wetter climate throughout much of the world, resulting in these alterations in tree growth, they propose. The main candidate for this disturbance is a volcanic eruption that took place on the Aegean island of Thera (SN: 4/16/88, p. 251), the researchers hold.

That volcanic blast, or perhaps another one that has yet to be identified, spewed out a blanket of dust that drastically reduced the amount of sunlight reaching Earth's surface, they propose. As a result, soil remained unusually moist that year and contributed to expanded growth of annual tree rings.

Archaeologists have recently uncovered pumice, presumably derived from the Thera eruption, in sediment surrounding the remains of a palace from ancient Egypt, Renfrew notes. The palace belonged to a dynasty traditionally thought to have assumed power in 1550 B.C. If Kuniholm's group proves correct about the 1628 B.C. date of Thera's eruption, substantial changes may have to be made in the chronology of ancient Egypt, says Renfrew.

However, an "unassailable causal link" does not yet exist between the Thera eruption and the unusual spurt of tree growth in ancient Turkey or elsewhere, the British researcher contends.

"We're saying we have evidence for a global climatic event in late 1629 B.C. or early 1628 B.C.," asserts Cornell's Maryanne Newton, a tree-ring researcher and a member of Kuniholm's team. "It wasn't necessarily the Thera eruption, but the Turkish sites in our study were downwind from Thera."

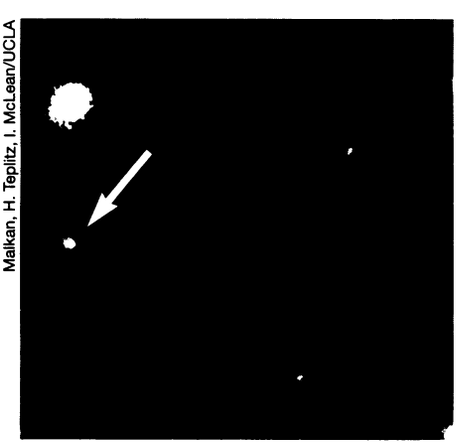
Although critical questions remain, Kuniholm's project "offers the best hope we have for a really sound chronology for the later prehistory and history of the Near East and Egypt—and indeed the eastern Mediterranean in general," Renfrew concludes. *— B. Bower*

A cluster of observations poses puzzles

If the life of the universe were a book, the later parts would be clearly legible. It's the early chapters that remain fuzzy.

Using the world's largest optical telescope, the 10-meter W.M. Keck atop Hawaii's Mauna Kea, several teams of astronomers have recently taken a leap back in time, sketching in some of the details about the cosmos shortly after its birth some 10 to 20 billion years ago.

In May, Judith G. Cohen of the California Institute of Technology in Pasadena and her colleagues reported that distant galaxies, viewed as they appeared when the cosmos was half its current age, were clumped together rather than distributed evenly across the sky. The finding suggested that this lumpiness in the cosmos may have arisen earlier than some theories can easily account for (SN: 4/27/96, p. 260). Now, another Keck observation hints that such clustering might have occurred earlier still, when the cosmos was less than one-fifth its current age.



Malkan, H. Teplitz, I. McLean/UCLA

This galaxy (arrow) is part of a newly found cluster that dates from when the universe was one-third its current age.

The new findings focus on the region surrounding the distant quasar BR 2237-0607. Last year, Richard G. McMahon of the University of Cambridge in England and Esther M. Hu of the University of Hawaii in Honolulu found what appears to be a young, ordinary galaxy in the neighborhood of the quasar (SN: 9/30/95, p. 212). The galaxy's measured redshift of 4.5 means that the light now reaching Earth left the galaxy when the cosmos was just a few billion years old. McMahon and Hu have spied a second galaxy in the vicinity, they reported June 10 at a meeting of the American Astronomical Society in Madison, Wis.

A grouping of two ordinary galaxies and a quasar does not necessarily a cluster make, McMahon emphasizes. Quasars, dazzling powerhouses that may represent an unusual type of galaxy, seem more likely than other objects to reside in groups. Yet McMahon says that the discovery, together with evidence of clustering later in the history of the cosmos, suggests that astronomers may find larger groupings in the early universe as telescopes like Keck deepen their view.

"Seeing even one object this far away is difficult, and so finding even another one is suggestive of clustering," says Mark A. Dickinson of the Space Telescope Science Institute in Baltimore.

"It's dicey; they really don't have enough data," says Cohen. But, she adds, the finding could be the "beginning of a great discovery."

Cohen says she and other astronomers, including Lennox L. Cowie of the University of Hawaii, have confirmed her team's evidence of clustering later in cosmic history by analyzing the Hubble Deep Field, the most detailed deep-sky images ever made. At a workshop in Cambridge next week, Dickinson plans to present observations of a cluster of galaxies dated slightly earlier than that of Cohen's team.

At the Madison meeting, Matthew A. Malkan and his colleagues at the University of California, Los Angeles reported finding two clusters of infant galaxies dating from about one-third the universe's current age. This places them even earlier in cosmic history than Dickinson's finds but later than those reported by Hu and McMahon. *— R. Cowen*

Growers bee-moan shortage of pollinators

Most people in the northern half of the United States will remember the winter of 1996 for record snows that seemed to take forever to melt. Apiculturists, however, will remember it as the winter their bees died.

"We've been hearing regularly of people who lost 80 or 90 percent of their [commercial] honeybees," reports Anita M. Collins of the Agriculture Department's bee research lab in Beltsville, Md. Honeybees, the most versatile and widely cultivated of natural pollinators, play a pivotal role in the fruiting or seed development of numerous plants, including at least 30 U.S. crops valued together at about $10 billion annually, according to Roger Morse of Cornell University.

The shortage extends beyond the snow belt and managed bee colonies, observes Gary P. Nabhan, of the Arizona-Sonora Desert Museum in Tucson. In Arizona, for instance, "we've seen a 70 percent loss in [wild] honeybees since 1991," he says. Nationally, he reports, only about 2.7 million wild and managed honeybee colonies exist—fewer than half as many as 50 years ago. "And half this loss," he notes, "occurred within just the last 5 years."

The pandemic spread of two parasitic mites has fostered this decline in the honeybee population. "We know they are everywhere now in the United States," Collins says of the mites, and "perhaps one-quarter of the [bee] colonies have both."

The tracheal mite, which entered the United States from Mexico in 1984, burrows holes through the inside wall of a bee's windpipe to get at the insect's equivalent of blood. The *Varroa* mite, which entered the country 3 years later, attaches to the outside of the honeybee and sucks out this bloodlike fluid.

The parasites weaken, but do not kill, the honeybees. However, Collins says, new data