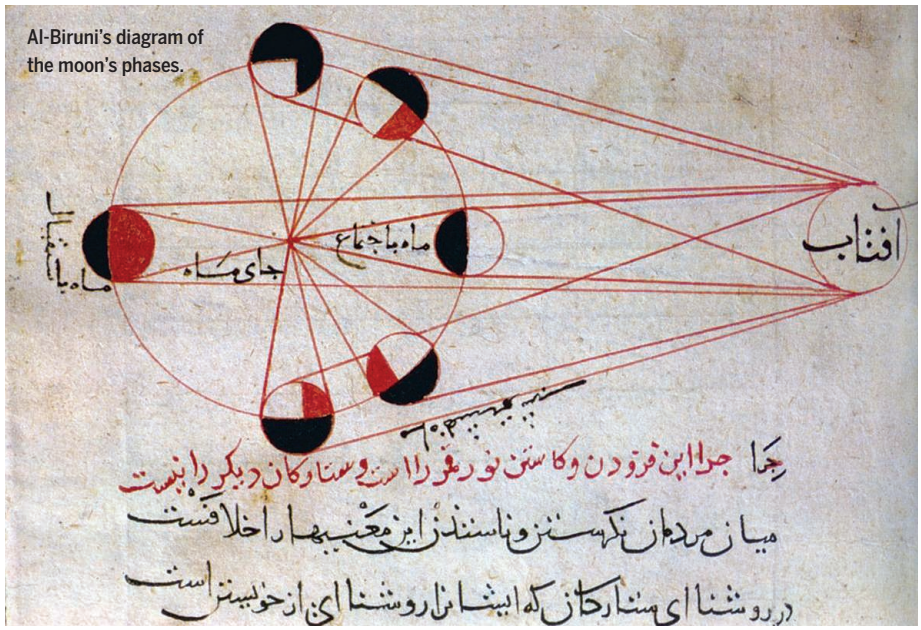
the D-Wave chip produced no quantum speedup. The researchers ran problems for different-sized groups of qubits, ranging from the chip's basic unit of eight to its total of 512. The computing time for the conventional computer increased exponentially with the number of qubits. But so did the time for the D-Wave machine. Troyer takes care not to overstate the finding: "We don't see quantum speedup, but that doesn't mean you won't see one eventually" for some other problem.

Indeed, the test problems may have been easy for the ordinary computer, too, says Texas A&M's Katzgraber. Choosing interactions at random, he explains, typically creates test problems in which qubits lock into a low-energy configuration only exactly at zero temperature. So at any higher temperature, thermal annealing can readily coax the system to the solution. Given the easiness of the problems for both machines, Katzgraber says, the study is like "two world-class skiers racing on the bunny slope." Hartmut Neven, director of engineering at Google, says his team has already found patterns of interactions for which the D-Wave machine beats simulated annealing.

However, some researchers doubt that a quantum annealer will ever produce a useful quantum speedup. Although computer scientists have proved that a dreamed-of universal quantum computer should excel at factoring, theory strongly suggests that in actuality a quantum annealer will produce no similar speedup for any problem, says Umesh Vazirani, a computer scientist at the University of California, Berkeley. "I would bet that there's not a speedup," he says. Neven counters that he is "convinced that we will be able to find problem classes for which a next-generation quantum annealer will outperform any classical algorithm."

Meanwhile, the sniping between D-Wave and its critics continues. D-Wave co-founder Geordie Rose recently told *Wired* magazine that Troyer's work was "total bullshit."

Such rhetoric rankles some researchers. By making claims that may not pan out, D-Wave could jeopardize the whole field of quantum computing, says Scott Aaronson, a computer scientist at the Massachusetts Institute of Technology in Cambridge. "If it becomes common knowledge that they're not seeing a speedup, then the same people who are backing them may turn and say, 'Well, I guess quantum computing is a failed idea,' " he says. In response to accusations of hype, D-Wave's Williams says, "We're a commercial company, and all commercial companies have to market their products and services." ■



Al-Biruni's diagram of the moon's phases.

PHOTO: REPRODUCTION FROM SEYYED HOSSEIN NASR, *ISLAMIC SOCIAL SCIENCE: AN ILLUSTRATED STUDY* (WORLD OF ISLAM FESTIVAL PUBL. CO., 1976)

HISTORY OF SCIENCE

Was America 'discovered' in medieval Central Asia?

Ancient texts suggest Silk Road polymath inferred the existence of unknown continents

By **Richard Stone**
in Samarkand, Uzbekistan

He was a Renaissance man long before the Renaissance. Abu Rayhan al-Biruni, born a thousand years ago in this region of Central Asia, calculated Earth's circumference with astounding accuracy and invented specific gravity, the measure of a substance's density compared to that of water. He rejected creationism, accepted that time has neither a beginning nor an end, and—5 centuries before Copernicus—argued that the sun might be the center of the solar system. Now, an influential scholar has proposed adding another laurel to that list: inferring the existence of America.

The discovery of America is bitterly contested, with vying claims on behalf of prehistoric peoples who crossed over Beringia or the Pacific Ocean, Norse seafarers who landed in Newfoundland around 1000 C.E., and the 15th century explorers Christopher Columbus and John Cabot. Biruni, who never laid eyes on any ocean, also deserves "to wear the crown of discovery," averred S. Frederick Starr, chair of the Central Asia-Caucasus Institute of the Johns Hopkins School of Advanced International Studies in Washington, D.C., at a conference on medieval Central Asia held here last month. "His tools were not wooden boats powered by sail and muscular oarsmen but an adroit combination of carefully controlled observation, meticulously assembled quantitative data, and rigorous logic."

Some experts are not persuaded. "There is a tendency these days to read too many modern discoveries into the works of the medieval scientists," says Jan Hogendijk, an authority on Biruni at Utrecht University in the Netherlands. "We don't say that Copernicus 'discovered' that the Earth moves around the sun simply based on the fact that he hypothesized that it does," adds Nathan Sidoli, a science historian at Waseda University in Tokyo, "so I don't see why we should say that al-Biruni 'discovered' the American continent."

But others think Biruni deserves credit for his prediction. "Assuming that the key passages in Biruni's texts have been correctly read, I see no reason to exclude al-Biruni from the list of early 'discoverers' of America," says Robert van Gent, a specialist on the history of astronomy at Utrecht University who attended Starr's talk here.

Biruni was one of a constellation of Cen-

tral Asian scholars who led an "Eastern Renaissance" spanning 7 centuries, from about 800 to 1500 C.E. These scholars include some of the greatest minds you've never heard of, and their achievements include the principles of algebra and trigonometry, the invention of the algorithm and the astrolabe, and the foundations of modern medicine. "These were tremendous figures," Starr says. Yet, he says, "This incredible effervescence in science has largely escaped our attention in the West."

Starr, an archaeologist by training who has made dozens of trips to Central Asia, is at the vanguard of a scholarly movement to document the Eastern Renaissance and the factors that nurtured it. At the crossroads of the vibrant cultures of China, India, the Middle East, and Europe, Central Asians became traders nonpareil, and for that they had to know how to calculate. "The Chinese were amazed that young boys in Samarkand were learning mathematics when they were 8 years old," Starr says.

Biruni boldly sorted scientific fact from fantasy.

The brightest star in the Central Asian firmament may have been Biruni. "He was really a universal genius," versed not only in the hard sciences and anthropology, but in pharmacology and philosophy as well, says Jules Janssens, a specialist on medieval Central Asia at the Catholic University of Leuven in Belgium. Biruni authored at least 150 texts, although only 31 have survived—and these are virtually unknown outside a small circle of scholars.

Born in 973 C.E. near the Aral Sea in present-day Khiva, Uzbekistan, Biruni used the height of the midday sun to calculate the latitude of his hometown when he was just 16. He traveled widely as an adult, and at a hilltop fortress near present-day Islamabad he devised a technique for measuring Earth's circumference using an astrolabe, spherical trigonometry, and the law of sines. (Like the ancient Greeks, Biruni was aware that Earth is round.) His calculation was a mere 16.8 kilometers off the modern value, Starr says. "I don't know where he became a data freak, but he's the real thing. His was an original kind of mind."

In a massive tome called the *Masudic Canon* completed in 1037 C.E., Biruni analyzed classical Greek, Indian, and Islamic astronomy and used "bold hypothesizing" to sort out credible claims from fantasy, Starr says. In another treatise, Biruni introduced the concept of specific gravity and applied it to scores of minerals and metals, making measurements accurate to three decimal points that Starr says Europeans could not match until the 18th century.

Most sensational of all may be Biruni's "discovery" of America. For the purpose of precisely determining the qiblah—the direction of Mecca during Islamic prayers—Biruni meticulously recorded coordinates of the places he visited, and compiled data on thousands of other Eurasian settlements from other sources. After plotting out the known world—possibly on a 5-meter-tall globe he is said to have constructed—he found that three-fifths of Earth's surface was unaccounted for.

"The most obvious way to account for this enormous gap was to invoke the explanation that all geographers from antiquity down to Biruni's day had accepted, namely, that the Eurasian land mass was surrounded by a 'world ocean,' " Starr relates in *Lost Enlightenment: Central Asia's Golden Age from the Arab Conquest to Tamerlane,* a book published last October. Biruni rejected that notion in a passage flagged by the Indian scholar Sayyid Hasan Barani in the mid-1950s but overlooked in the decades since, Starr says. Biruni argued that the same forces that gave rise to land on two-fifths of our planet must have been at work in the other three-fifths. He concluded that one or more landmasses must lie between Europe and Asia, writing, "There is nothing to prohibit the existence of inhabited lands."

In the December 2013 issue of *History Today,* Starr wrote that Biruni's "*modus operandi* strikes one as astonishingly modern, a voice of calm and dispassionate scientific enquiry sounding forth from the depths of the irrational and superstitious medieval world." The Eastern Renaissance wound down, Starr says, when "a pall of suspicion fell on science" in Central Asia. For centuries, Biruni and other scholars of that era—like America—awaited rediscovery. ■

SCIENTIFIC PUBLISHING

Secret bundles of profit

Study lifts veil on journal price negotiations

By **John Bohannon**

For many purchases, price comparisons are a few mouse clicks away. Not for academic journals. Universities buy access to most of their subscription journals through large bundled packages, much like home cable subscriptions that include hundreds of TV stations. But whereas cable TV providers largely stick to advertised prices, universities negotiate with academic publishing companies behind closed doors, and those deals usually come with agreements that keep the bundled prices secret. After years of digging, and even legal action, a team of economists has pried out some of those numbers.

The results of their investigation, published on 16 June in the *Proceedings of the National Academy of Sciences* (*PNAS*), reveal that some universities are paying nearly twice what universities of seemingly similar size and research output pay for access to the very same journals. For example, the University of Wisconsin, Madison, paid Elsevier $1.22 million in 2009 for a bundle of journals, while the University of Michigan, Ann Arbor—a university with similar enrollment and number of Ph.D. students—paid $2.16 million for the same bundle. At *Science*'s request, the authors even calculated a potential measure of how good or bad a deal U.S. universities are getting, providing a graphic view of the price spread (see p. 1333). (AAAS, *Science*'s publisher, offers bundled pricing for its three journals but was not included in the *PNAS* study.)

The price of journals has become a source of friction between academics and publishers. Publishers pay nothing for most of the labor that goes into academic articles—the writing and revision by authors, the quality control by volunteer peer reviewers—yet the largest of these companies reap annual profits upward of 35% on billions of dollars of revenue. According to the industry leader, Amsterdam-based Elsevier, the high profits are the result of innovation and efficiency, while the subscription bundling gives universities access to journals "at a substantially discounted rate." But according to Peter Suber, director of the Office for Scholarly

PHOTO: COURTESY OF THE ACADEMY OF SCIENCES OF UZBEKISTAN