

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.

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 medi-

eval 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 ana-

lyzed 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—



Biruni boldly sorted scientific fact from fantasy.

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

Communication at Harvard University, publishing companies “use bundling to protect second-rate or little-used journals from cancellation,” and they enforce secrecy “partly to limit the bargaining power of buyers and partly to hide the results of this unequal bargaining power.”

The journal pricing investigation began in 2009 when Theodore Bergstrom, an economist at the University of California, Santa Barbara, faced a time crunch. “I decided that I didn’t have time to referee all the papers that I was asked to,” he says. “On a whim, I decided to give priority to journals with relatively low subscription prices. ... I was amazed at what the commercial [publishers] were charging and much annoyed that they thought I should work for them for free.” Since then, Bergstrom has become a data

activist, contributing to projects that measure cost and value in academic publishing, such as the Eigenfactor project and journalprices.com. He has gotten pushback. “Some librarians defended the commercial publishers by suggesting that the prices we quoted were misleading because they didn’t account for bundle discounts,” Bergstrom says. “So we set out to find out bundle prices.”

That was easier said than done. Bergstrom teamed up with two other economists—Preston McAfee, chief economist at Microsoft in Redmond, Washington, and Paul Courant, at the University of Michigan, Ann Arbor—and reached out directly to librarians at nearly 100 universities and university consortia across the United States. Only half shared the terms of their bundled journal subscriptions. For the rest, the team requested the subscription contracts through the various Freedom of Information Act laws covering each state-funded institution. Some publishers fought back. In 2009, Elsevier even sued one university, Washington State University in Pullman, to set a precedent for blocking the release of bundled subscription terms, claiming that the deals are a trade se-

cret. A state judge ruled against Elsevier.

The team’s analysis, which looked at the prices charged by publishers in 2009, indicates that the secret haggling between university librarians and academic publishers produces some startling disparities. The University of Texas, Austin, paid \$481,932 for Springer journals, while an institution with far fewer Ph.D.s, the University of Miami in Florida, paid \$553,923. For access to Wiley’s journals, the University of Missouri, Columbia, paid \$233,659, while the smaller University of Oklahoma paid \$500,744.

Publishers and some academic librarians caution that the numbers can be misleading. The price that any university pays a publisher “doesn’t tell you the whole story,” says Doug Way, a librarian at the University of Wisconsin, Madison. A university’s prior his-

deal,” says Elizabeth Fish, a librarian at the University of Miami. “A recent internal study showed our cost for a Springer article download at about \$2.00.”

In his analysis for *Science*, Bergstrom compared deals at universities by using a statistical model based on the number of full-time students enrolled and the number of Ph.D. degrees granted. (A spreadsheet with that data can be found at <http://scim.ag/JournalBundles>.) “We realize that a simple linear equation involving enrollment and Ph.D.s does not fully explain the value of journals to universities,” he says. “On the other hand, we think that it may be helpful for librarians to compare the price they are paying with prices paid by their peers.”

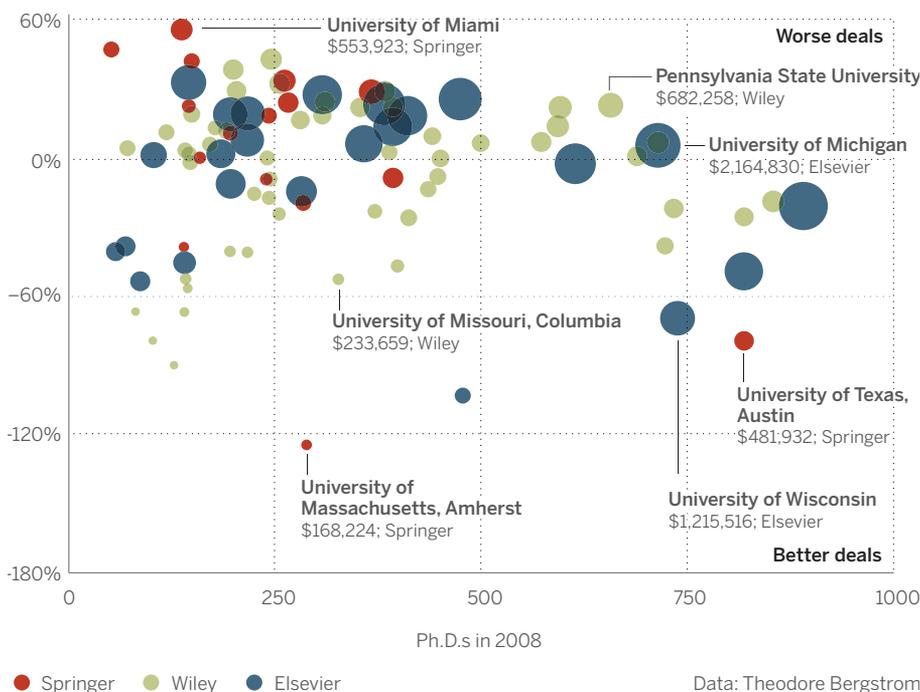
Elsevier declined to comment on the study, and Springer could not be reached. “Wiley offers a range of flexible pricing and licensing options that include the full collection as well as a number of other collection options,” the company told *Science* in an e-mail. “We recognize that there is no one size or type of deal that suits all of our customers.”

Will the pricing disclosure make a difference? “I think it’s possible that publishers could try to level or adjust the pricing to make it seem more fair to subscribing libraries from a comparative standpoint, but the total revenue going to the publishers won’t get smaller,” predicts Scott Stangroom, who coordinates journal acquisitions for the University of Massachusetts, Amherst.

“We have a collective-action problem,” says Tim Gowers, a mathematician at the University of Cambridge in the United Kingdom who launched a petition calling for a boycott of Elsevier. “If all libraries were simultaneously to refuse to sign any more Big Deals and switched instead to paying for journal subscriptions individually, then the market rate for the journals would be at a level where they reflected the actual value of the subscriptions to the universities, which is much lower than the current list prices.” ■

## Journal prices: good deal or not?

Payment premium (% > 0) or discount, based on expected price from modeling; circle size reflects university’s 2009 payment



cret. A state judge ruled against Elsevier.

tory with a publisher can play into the negotiation and strongly influence the final price, he says. For example, Way says that his university had been “canceling large numbers of subscriptions for a number of years before it entered into [the bundled] ‘Big Deal’ ” with Elsevier, a history that helped the university negotiate a better rate.

Also missing are data about how many journal articles are actually downloaded over the course of a year. “Our use-analysis of the Springer packages shows we got a good

collective-action problem,” says Tim Gowers, a mathematician at the University of Cambridge in the United Kingdom who launched a petition calling for a boycott of Elsevier. “If all libraries were simultaneously to refuse to sign any more Big Deals and switched instead to paying for journal subscriptions individually, then the market rate for the journals would be at a level where they reflected the actual value of the subscriptions to the universities, which is much lower than the current list prices.” ■